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APRIL 1959

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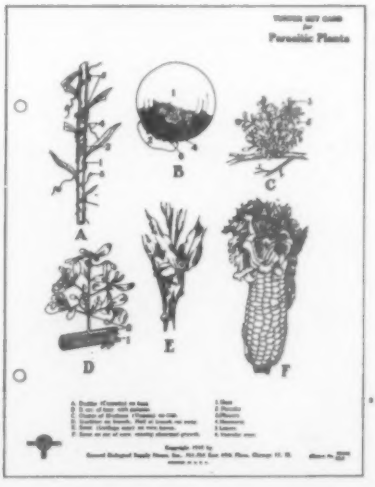

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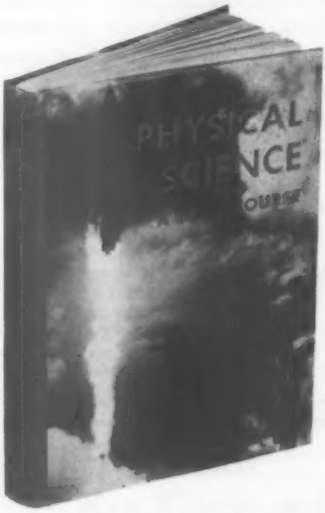

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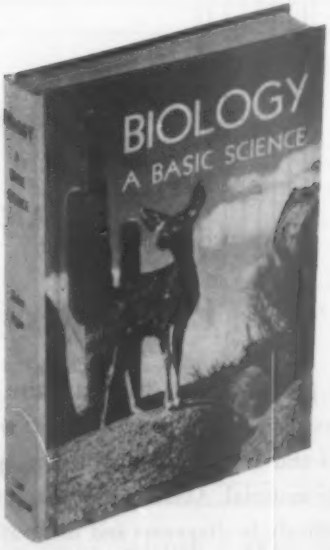

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CONTENTS FOR APRIL, 1959

Student Interest in Science and Mathematics and the "Introductory" Teacher—*Vernon W. Stone* 249

Thoughts on Science Fairs—*Maitland P. Simmons* 253

New National Programs in Science Education—*Walter J. Peterson* 255

ſ—Robert Fertig 266

Eggs and Physics—A Class Experiment, Part II—*John Satterly* 273

Recommendation for the Preparation of High School Teachers of Science and Mathematics—1959—*Alfred B. Garrett* 281

The Role of State Committees in Developing a Conservation Education Program—*Richard L. Weaver* 290

The Elementary School Science Library for 1958—*Paul E. Kambly* 294

One Hundred Years Without Darwinism Are Enough—*H. J. Muller* 304

Changing Chemical and Biological Conditions in Oneida Lake, New York —*Wilford A. Dence* and *Daniel F. Jackson* 317

Problem Department—*Margaret F. Willerding* 325

Books and Teaching Aids Received 329

Book Reviews 330

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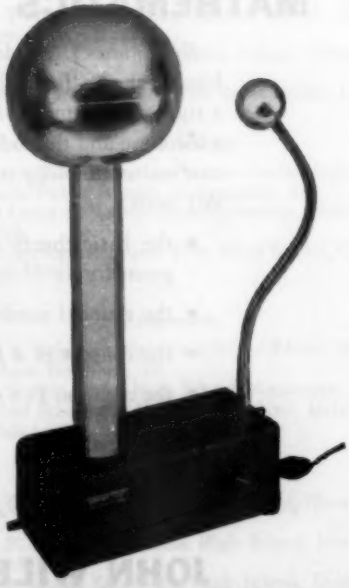

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SCHOOL SCIENCE
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VOL. LIX APRIL 1959 WHOLE NO. 519

Student Interest in Science and Mathematics and the "Introductory" Teacher

Vernon W. Stone

Professor of Business Education, Maryland State College, Division of University of Maryland

Frequently we are led to believe that a student will acquire an automatic, objective interest in a given course or vocational area because of his general ability or a related aptitude. However, there is some evidence to suggest that exposing the student to the *right* teacher at the outset has important implications for identifying and kindling student interest. Accordingly, the teacher who can inspire students has always been one of the genuinely valuable assets at the disposal of the schools.

Without attempting to resolve the merits of curricular requirements or of comparative course difficulties, some attention should be given a generally unexplored technique for increasing interest and subsequent enrollment in science and mathematics subjects. It is recognized that many science and mathematics teachers are regarded as outstanding teachers in every way. Often, though, teachers in these areas are not considered "the best teachers" by the students. Whether such is a function of the inherent nature of the subject-matter content or whether it is a function of less tangible factors may be debatable. Notwithstanding, the extroversion—so necessary for most teaching—may, at times, prove to be lacking among teachers of objective-type subjects.

It must be made clear that this is not a report of an experiment. No controls were employed; no cross-validations were established. The writer's purpose is merely to indicate how one high school attacked the problem and met with a degree of success.

The subject school is located on the West Coast. In spite of the request from the chief administrative officer of that school to withhold its name, the findings and applications are still of interest. The school conducted a study with the objective of implementing an idea initiated by the principal. The principal, whom we shall identify as "Mr. H. S.," was well aware of certain implications of the science-mathematics problem. "The first impression," he had voiced, "is the last impression." Here, the principal referred to the students' impressions aroused by their initial experiences in the areas. Consequently, it was believed that if the early classroom experiences in these areas were made interesting for the students, enrollments in the specialized courses might increase. In the school under discussion, the decision was that "the best teachers" would be used to teach the 9th-grade subjects in science and mathematics—general science and algebra, respectively.

Table I shows the teaching areas of the fourteen teachers on the faculty of the school. The three mathematics teachers are designated by F, I, and K; the two physical science teachers, C and G. The remaining teachers are distributed in the other areas as shown.

TABLE I

TEACHERS BY LETTER DESIGNATIONS AND TEACHING AREAS

Teachers	Teaching Areas					
	Math.	Phy.Sc.	Soc.Sc.	L.A.	B.E.	Mus.
A			×			
B				×		
C		×				
D			×			
E					×	
F	×					
G		×				
H				×		
I*	×					
J				×		
K	×					
L			×			
M						×
N					×	
Totals	3	2	3	3	2	1

* Part-time teacher.

During the school year 1953–54, the principal asked all of the 380 students, the total enrollment of the school, to vote, in writing, for "the best teacher." Each student employed his own criteria in reaching his decision. The results were then tallied and the order of "pop-

ularity" was indicated in descending frequency of the number of votes received by each teacher. Table II contains these data.

TABLE II

RANK ORDER OF "THE BEST TEACHER" BY LETTER DESIGNATION AND TEACHING AREA

Rank Order	Teacher	Teaching Area
1	H	L.A.
2	E	B.E.
3	L	Soc.Sc.
4	B	L.A.
5	I*	Math.
6	A	Soc.Sc.
7	J	L.A.
8	C	Phy.Sc.
9	D	Soc.Sc.
10	N	B.E.
11	M	Mus.
12	K	Math.
13	F	Math.
14	G	Phy.Sc.

* Part-time teacher.

During the summer of 1954, the three highest-ranking teachers—H, E, and L—were given an opportunity to review general science and algebra. Each of the three teachers, fortunately, had had some training in the two subjects. Teachers without such previous exposure may have encountered difficulty in attempting to acquire adequate content during a summer. Furthermore, Teacher E had taught 9th-grade algebra for one semester at another school. The idea was for these "new" teachers to teach the two subjects in the pedagogical manner which had led to their being labeled "the best teachers." For two months of the summer, the teachers attended a nearby university and reviewed general science and algebra content. Then, during the last month, they prepared unit plans, lesson plans, and other materials for the ensuing fall.

Table III shows the high school enrollment for the year the student vote was taken, 1953–54, and the three succeeding years. The average annual enrollment was approximately 380.

Table IV shows enrollments in required and elective science and mathematics subjects. Since general science and biology are required of all students, the effect of "the best teacher" plan can be noted with respect to only chemistry and physics, elective subjects for the 11th and 12th grades, respectively. Similarly, the effect of the plan in the mathematics area can be noted with respect to only solid geometry

and mathematical analysis. For the three years following the initiation of the plan, a steady increase in enrollment is noted in both the science and mathematics areas.

TABLE III

ENROLLMENT OF THE SCHOOL BY YEAR AND GRADE

Year	Total Enrollment	Grade			
		9th	10th	11th	12th
1953–54	380	135	97	81	67
1954–55	387	142	99	83	63
1955–56	372	141	96	79	56
1956–57	383	138	101	80	54

TABLE IV

ENROLLMENTS IN SCIENCE AND MATHEMATICS SUBJECTS BY SUBJECT STATUS AND YEAR

Subject	Subject Status		Year			
	Required	Elective	1953–54	1954–55	1955–56	1956–57
Science						
Gen. Sc.	9th		135	142	141	138
Biol.	10th		97	99	96	101
Chem.		11th	11	10	15	20
Physics		12th	7	9	13	17
Mathematics						
Algebra	9th		135	142	141	138
Plane Geom.	10th		97	99	96	101
Solid Geom.		11th	10	11	18	21
Math. Analys.		12th	9	8	15	18

Table V shows the numbers and percentages of juniors and seniors electing science and mathematics subjects. During the three-year period in question, marked increases are to be noted.

This study focuses attention on a significant aspect of the teaching-learning process. When increased enrollment in electives is employed as an index, there is some basis for the suggestion that student interest may be created, kindled, and developed, initially, through an avenue other than subject-matter knowledge. Undoubtedly, "the best teachers" can educe student interest; but the science-mathematics specialists must sustain it and make it meaningful.

TABLE V

NUMBERS AND PERCENTAGES OF JUNIORS AND SENIORS ELECTING SCIENCE AND MATHEMATICS SUBJECTS BY YEAR

Year	Total Jr. & Sr. Enrollment	No. Jrs. & Srs. Electing Sc. and Math.	Percentage of Total Jr. & Sr. Enrollment
1953–54	148	37	25
1954–55	146	38	26
1955–56	135	61	45
1956–57	134	76	57

Thoughts on Science Fairs

Maitland P. Simmons

Irvington High School, Irvington, New Jersey

In recent years throughout our country, science fairs have become extremely popular, with only a few extra-curricular activities exceeding their phenomenal growth. Last year according to Science Service, teen-age scientists exhibited in home-town science fairs approximately 460,000 science projects, an increase of 87.5% over the previous year. From the 146 affiliated regional and state fairs, 281 finalists from 39 states including those from the District of Columbia, Alaska, Hawaii, Japan, Germany, and France competed in the National Science Fair at Flint, Michigan. It is interesting to note that more than 30,000 people jammed the doors of this fascinating exhibit area.

Because of this ever-growing popular interest and as a helpful aid to classroom teaching, the author[1] takes pleasure in suggesting several pertinent helps concerning quality long-range scientific projects. For specific details relative to techniques, consult the article, "Let's Join the Science Fair Winners."[2] For basic research, it is highly desirable that the prospective students have superior ability, exceptional scholastic achievement, and good mental and physical health. Other facets include power of expression, developed sense of adaptability, leadership, intellectual honesty, and facing up to adversity. However, from recent studies it would seem that a true and sustained interest in your work is even more important. Above all, these special ability, inquiring-minded students should have parental approval followed by periodic conferences with the sponsoring teacher.

[1] Program Chairman for the Greater Newark Science Fair Committee at the Newark College of Engineering and Co-chairman of the local committee on student exhibits for the NSTA Convention at Atlantic City.

[2] Simmons, Maitland P. "Let's Join the Science Fair Winners." *The Science Teacher*, 24:225–227, September, 1957.

Next, if these gifted students manifest a keen interest and a genuine desire for this type of intellectual experience, they should then choose an appropriate problem in their field of special interest. With this accomplished, it now becomes the chief role of the teacher in these science-learning opportunities to act as a resource person who makes references available. For a variety of valuable ideas and factual information from different subject matter areas, search constantly in your school, town, nearby university, and specialized library for the most recent publications such as the *New York Times*, *Scientific American*, *Journal of Chemical Education*, *Science News Letter*, *Turtox News*, *Popular Mechanics*, *Popular Science*, *Current Science and Aviation*, and *Science World*. Success with a science project depends largely on how much you know about your topic.

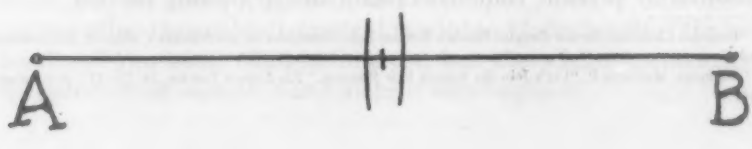
After reading widely, gathering data, and working when possible with professional scientists and technicians in research laboratories, the well-informed future scientists should then organize and present their factual materials in a logical order. Finally, they must evaluate their own activity as to the learning of new ways of doing things. Careful and thorough planning is the keynote of success. Try to anticipate the difficulties you will encounter and forestall as many as possible by deliberate and intelligent planning. The work is entirely voluntary and done out of school.

One of the all-important outcomes from these stimulative student-centered experiences is self-motivation, so essential to a most rewarding educational activity. The enthusiasm and accomplishments of the Irvington High School young scientists, as seen by the illustrations, testify as to the many values inherent in this type of effective experience.

MIDDLE POINT

There is a standard method for bisecting a line by using the common chord of two equal circles centered at the ends of the line. But the unavoidable width of lines drawn with pen or pencil, robs this method of its geometrical accuracy, and it is reported that professional draftsmen prefer an approximating method as being quicker and actually more accurate in practice. For a bisection (see Figure below) they guess at half of the line, lay this off at each end, and take the mid point of the short interval by eye-estimate.

W. R. R.



New National Programs in Science Education[1]

Walter J. Peterson

Head, Special Projects in Science Education Section, National Science Foundation, Washington, D. C.

I appreciate the opportunity to participate in this important conference which brings together an impressive gathering of experienced Michigan educators to consider some of our common problems. It is always a pleasure to come to Ann Arbor, and especially so on an occasion that makes it possible to greet so many friends and acquaintances.

We are meeting because we are all aware of the formidable problems that confront us in providing first-rate educational opportunities for our young people. I think you will agree with me that the spectacular developments of the past year did not in any sense produce these problems but have merely been instrumental in securing attention and action on matters long overdue. The case for concern has been, and is, genuine. The real challenge for the coming years is to educational leadership—lay and professional—at all levels, national, state, and local. If this leadership is wise, our schools and colleges, our whole system of education will fare well.

So far as the Federal Government is concerned the past year has seen action in a number of areas. I will not attempt to review all of these here. Among the significant measures passed in Congress was the National Defense Education Act of 1958—the first general aid to education legislation to be enacted in this country since the Morrill Act of 1862 and 1890. I shall not review the provisions of this bill for I am sure that they are familiar to you, but they do provide, through the Department of Health, Education and Welfare, significant assistance for both teachers and students (Titles II and IV), as well as needed funds for high school science-laboratory refurbishment and equipment (Title III). One is glad to note that the bill is not restricted to science alone, but provides aid in the important area of foreign languages (Title VI) and also makes provision for research and experiments in the use of modern communications media—TV, radio, films, etc.—for educational purposes (Title VII).

With the substantial increase in funds appropriated by the Congress, the National Science Foundation is augmenting a number of existing programs and initiating several new ones in the field of science education along lines that have been previously tried and found

[1] Prepared for the 12th Annual Conference on Higher Education and the Michigan College Association, Ann Arbor, Michigan, November 19–20, 1958, and to be published concurrently in the *Addresses Given at the Annual Conference on Higher Education in Michigan, November 19 and 20, 1958*, University of Michigan Official Publication, 1958.

useful. These programs complement those being undertaken by the U. S. Office of Education, under the authorization of the National Defense Education Act.[2] The Foundation continues to work directly with academic institutions and the scientific community, while the Office of Education works generally through the State boards of education.

The Foundation has been encouraged in its decision to proceed along paths charted in the pre-Sputnik days by the endorsement given by the President in his education message to the Congress last January. In that message the President stated in part:

> The programs of the National Science Foundation designed to foster science education were developed in cooperation with the scientific community under the guidance of the distinguished members of the National Science Board. They have come to be recognized by the education and scientific communities as among the most significant contributions currently being made to the improvement of science education in the United States.

Before summarizing the projected program activities of the Foundation for the coming year, it may be appropriate to review some of the principles by which the Foundation has been guided in developing these programs:

1. Any attack on the problem of education in the sciences must be made with mutual and sympathetic cooperation between research-scholars and the teacher-scholars in the educational community. Without this cooperation, any program in education will fail to achieve its primary objectives. Responsibility for this cooperation rests with the scientists and educators, and in making a grant to a college or university the Foundation assumes that the institution accepts this responsibility.

2. We recognize that the teacher is a key to the quality of the education of youth, and if we are to support excellence in training we must seek methods to assist teachers. Financial limitations brought about by the depression caused teaching loads to increase greatly. Teachers found less and less time for intellectual refreshment and for keeping up to date in their fields. In addition, during the last war and down to the present time, an increasing amount of federal and industry-sponsored developmental work has been undertaken by colleges and universities, making further inroads on the time of teachers. The difficulties of teachers in finding leisure time for intellectual pursuits of their own choosing and quiet, scholarly conversation with their students have thus been compounded. The problem, then, is to devise methods to give teachers time for intellectual refreshment, opportunities to keep abreast of new developments in their subject-

[2] See Committee Print, 85th Congress, 2nd Session, The National Defense Education *Act of 1958*. A Summary and Analysis of the Act, September 5, 1958 Higher Education, Vol. XV, No. 2, U. S. Dept. of Health, Education and Welfare, October 1958.

matter fields, sufficiently high stipends to compete with other opportunities to augment their incomes to meet high family expenses, and tools for necessary laboratory instruction.

3. Because science and technology have developed so rapidly during the past fifty years, the material being presented to youth, especially in high schools (but in colleges as well) is often both out of date and inadequate, describing applications only, without sufficient discussion of the basic scientific principles involved. It is time for a review of the crucial experimental discoveries and theoretical developments which are directing the progress of science and technology. Support should be given for studies to determine the material necessary for basic understanding of science for presentation to high school and college students. The critique of the subject-matter material should be made by the scientific community, and the method of presentation should be worked out jointly by teachers and scientists.

4. It is recognized that no amount of money can substitute for wisdom, initiative and sustained effort in solving the problem. One of our main tasks is to select from among many proposals for support which come to the Foundation, those which show the most promise in success in meeting the problem. After a grant is made, the responsibility for the proposed activity belongs to the grantee.

Now let me review in more detail the various educational programs of the Scientific Personnel and Education (known by the Foundation Staff as SP&E). I will limit my discussion principally to new programs and to those old programs which are being expanded appreciably in this fiscal year.

The Fellowship Programs. There are now seven different fellowship programs. Four of these, the Predoctoral, Postdoctoral, Senior Postdoctoral and Science Faculty Fellowship programs are continuing programs, and I am sure that most of you are familiar with these. The following new fellowship programs are being implemented:

Summer fellowships for secondary school science and mathematics teachers. This program, which supplements the Summer Institute Program, is being designed to improve the preparation of science and mathematics teachers in secondary schools. According to present plans, the first awards will be available for tenure during the summer of 1959. The program has tentatively been budgeted at a level which would permit approximately 750 fellows to begin study during the summer of 1959.

Fellows will follow individually designed programs of study directed toward improving their competence as high school teachers of science and mathematics. Applicants will be required to present, as a part of their applications, appropriate plans of study and evidence that they can be carried out at the proposed institutions. Tenures as

short as one summer session or as long as three full summers are offered. Stipends will be computed at the rate of $75 per week and dependency allowances at $15 per week per dependent. A limited allowance will be available for travel of the Fellow to and from his fellowship institution. It is expected that this program will be announced this month, with a deadline for receipt of applications on January 19, 1959.

Summer study program for graduate teaching assistants. This program is designed to make it possible for graduate teaching assistants in science and mathematics to continue their academic study during the summer sessions, and to help improve the attractiveness of teaching assistantships as a means of graduate student support. The program, as planned, will be administered by cooperating graduate institutions for summer support of graduate students who are teaching assistants during the academic year. Plans provide for preliminary evaluation of applicants by the Institutions followed by central panel review, with final selections to be made by the Foundation. This program has been announced and may provide support for approximately 600 graduate teaching assistants during the summer of 1959. Fellows may receive a stipend computed at a rate not to exceed $75 per week and not less than $50 per week, the rate within these limits to be determined at the discretion of the institution.

Cooperative Graduate fellowships. This new program differs from the Predoctoral Fellowship Program in that graduate institutions will, in effect, request funds for fellowship support for individual graduate students of science, mathematics, and engineering whom they have recommended. Cooperating institutions may submit recommendations for specified numbers of applicants—determined by formula—who will be screened by a central panel, with final selections to be made by the Foundation, as required by law. Institutions will be advised of the names of those selected, and payments will be made to the institutions for disbursement to the Fellows. In addition to the $2,200 stipend for twelve months for each Fellow, each institution will receive $1,800 to aid in covering costs of education of the Fellow. Preliminary budgeting for this program would provide 1,000 fellowships from fiscal year 1959 funds.

The institutes programs. Improvement of subject matter knowledge of teachers of science is the primary purpose of the programs included under this heading. The institutes are held on college and university campuses in all parts of the country and offer courses in science and mathematics especially prepared to meet the needs of high school and college teachers. The instructional staff of the institutes is usually composed of staff members at the home institution and a number of visiting professors from other colleges and universities chosen for

their high competence and skill as teachers.

Summer institutes for high school teachers of science and mathematics. There will be a considerable expansion of the summer institutes programs in the summer of 1959. Present planning provides for 320 institutes for high school teachers, as compared with 118 for the summer of 1958. As in the past, some of these institutes will be designed for both high school and college teachers.

Academic year institutes. Since the beginning of the academic year 1956–57, the Foundation has administered a program of specially designed year-long courses of study at selected universities for high school science and mathematics teachers. It has awarded grants for 19 such institutes for the school year 1958–59, and expects to increase the number to about 30 for 1959–60.

In-service institutes for high school teachers. In-service institutes are especially designed to meet needs of high school science and mathematics teachers for supplemental instruction in the subject matter of science through courses offered on Saturdays or during after-school hours. Like other Foundation institute programs, in-service institutes are conducted by colleges and universities through grants from the Foundation. The Foundation will support 85 in-service institutes for high school teachers of science and mathematics during the academic year 1958–59. A considerable expansion of this program from fiscal year 1959 funds is expected.

Summer institutes for elementary school teachers and supervisors. It is recognized that careers in science, engineering and mathematics often start in the elementary schools. In order to help determine effective means of increasing the quality of science and mathematics instruction at the elementary level, a limited experimental program of summer institutes (probably 10) for supervisors and teachers will be supported.

Summer conferences for college teachers. A number of short conferences (of about 2 weeks duration) for college teachers of science and mathematics have been supported in the past by the Foundation on exploratory basis. Since such conferences have proved to be effective, it is planned to support approximately 20 such summer conferences for the summer of 1959.

Special Projects in Science Education

The Special Projects in Science Education Section is concerned principally with the experimental testing and development of promising new ideas for the improvement of science instruction, and with new and more effective methods of increasing the understanding of science on the part of our young people. In a sense, many of the activities of this Section are research studies, somewhat analogous to

the Foundation's activities in support of basic research.

Programs directed toward secondary school students. These projects are planned by universities, colleges, scientific societies, and research organizations to enlist the interest in and understanding of science, mathematics, and engineering by students in the secondary schools.

Visiting Scientists (Secondary Schools)

Outstanding scientists and engineers are enabled to visit secondary schools to make personal contacts with students and teachers, to acquaint them with the sciences as vital activities and to offer such counsel concerning careers and educational matters as may be appropriate. These visits stimulate an interest in science on the part of the students, and at the same time offer support, prestige, and professional advice to the teacher. Professional scientific societies in various disciplines plan, set up and administer the associated projects.

Traveling Science Library Program

This program is conducted for the Foundation by the American Association for the Advancement of Science for the primary purpose of making available to high schools on a loan basis carefully selected books on science and mathematics. During the school year 1957–58, fifty-four sets of 200 books each were circulated among 216 high schools. Plans during the current year 1958–59 call for the circulation of 365 such sets among approximately 1,350 schools. A list of the books in the Traveling Science Libraries is published separately and is given wide distribution. A larger and more comprehensive list of science and mathematics books for secondary school and community libraries is being prepared, and a special list of science and mathematics books available in inexpensive paperbound editions is also issued to encourage students who wish to buy them for their own use.

Traveling Science Demonstration Lecture Program

This program provides opportunities for secondary school students and teachers to witness special science lecture-demonstrations in physics, chemistry, biology, and mathematics. Especially trained secondary school science teachers present the demonstrated lectures. Heretofore, the training of these teachers has been done exclusively at the Oak Ridge Institute of Nuclear Studies with joint sponsorship of the Atomic Energy Commission. This program will be expanded to provide five additional regional training centers for the traveling teachers. For the year 1959–60, 140 traveling teachers will be trained under this expanded program.

Science Clubs and Student Science Projects

This program stimulates interest in science and in scientific and

engineering careers among students below the college level by supporting extracurricular science projects under the guidance of national youth organizations. Since 1952, the National Science Foundation has been providing a limited amount of support to Science Clubs of America, administered by Science Service, Inc., a non-profit organization with other sources of income. It is hoped that similar support can be extended to other national organizations to assist them in building up science-oriented aspects of their programs.

Summer Training Program for Secondary School Students

A primary purpose of this program is to encourage the scientific interests of high-ability secondary school students by providing them with opportunities to participate in study and research programs set up especially for them by interested college groups and non-profit research organizations. Programs in this area include short summer institutes conducted by universities and colleges to supplement the regular secondary school science programs, and also research participation programs in which students work along side experienced scientific investigators, thus obtaining first-hand knowledge of research methods and techniques.

State Academies of Science

State Academies of Science and similar non-profit scientific societies operating within a state or region will be supported under this program in carrying out specific projects to improve the status of science and science education. Most such projects are expected to comprise either (1) collaborative efforts by professional scientists and high school science teachers to improve science instruction, or (2) coordinated programs for stimulating interest in science among young people, principally at the pre-college level, by providing opportunities for science experience.

Career Information

This program will support the development and dissemination of authoritative facts about careers in science and engineering to high school students, guidance counselors, and science teachers through publications and conferences sponsored by the professional scientific and engineering societies and other qualified non-profit agencies.

College Programs and Teacher Improvement Programs

The programs in this category are designed to nurture the scientific education of superior college students of the sciences, mathematics, and engineering, and to improve the scientific background of science teachers.

Visiting Scientists (Colleges)

This is a program which enables distinguished scientists and engineers to visit small colleges and universities for a period of several days to give lectures, conduct classes and seminars, and to meet students and faculty members on a formal as well as informal basis in order to stimulate interest in science. The program is administered through grants to the appropriate professional scientific societies in mathematics, chemistry, physics, biology and astronomy. It is expected that the program will be extended to include other scientific disciplines such as the earth sciences, meteorology and engineering.

Undergraduate Science Training Programs

These programs are designed to provide promising undergraduates in mathematics, science, and engineering with enriched opportunities for accelerated scientific study, through (1) laboratory training programs, and (2) undergraduate science institutes. In the laboratory training programs undergraduates will be given the opportunity to participate in research programs alongside faculty members or advanced graduate students, either during the summer or part-time during the academic year, so that they may have direct experience with the problems and techniques of research. In the undergraduate science institutes support will be given to a limited number of especially designed curricula in science or mathematics for exceptional students involving such features as individual study, seminars, research projects, with the aim of securing superior undergraduate instruction as a sound basis for advanced graduate study.

Research Participation Program for Teacher Training

Through participation in laboratory research programs of colleges and universities during the summer, secondary school science teachers and science teachers in small colleges will have an opportunity in this program to increase their professional background and thus to improve their classroom teaching.

Supplementary Training Programs for Science Teachers

Science teaching is not a static profession, and the science teacher needs frequent opportunity to obtain supplemental training in order to keep abreast of new developments in his teaching fields. While the Foundation's Institutes and Summer Fellowships for High School Teachers offer many opportunities for such study, there is need for support for certain projects not provided for in these established programs. This program offers a wide variety of opportunities for the improvement of the subject matter qualification of high school and

college teachers. These include: (1) short conferences and symposia in specialized aspects of science and new developments in scientific knowledge; (2) work conferences to study improvements in science curricula, in teaching procedures, and in the dissemination of scientific knowledge; and (3) group study programs designed to provide instruction in the sciences for teachers unable to participate in institutes or conferences because of factors such as geographical isolation. All of these programs and conferences will be conducted by colleges, universities, scientific societies, and similar institutions.

International Science Education Programs

It is the primary objective of these programs to strengthen our Nation's total scientific effort and particularly our science education programs by providing opportunities for American scientists and educators to engage in cooperative science education activities with their colleagues in other countries, and thus assist them to keep abreast of the current state of scientific developments and science education practices throughout the world. Conferences, curricular studies, and teacher training programs will be undertaken in cooperation with other interested nations. Support will also be given to American scientists and educators participating in exchange missions primarily concerned with the comparative study of science education systems.

Course Content Improvement Studies

Progress in the sciences has been so rapid in recent years that courses in science and mathematics now offered in most secondary schools no longer reflect either the current state of knowledge or the attitudes of mind which characterize modern scientific study. The course work in mathematics that now makes up the instructional program of many modern high schools is that which has been taught essentially unchanged for approximately half a century. Similarly physics, chemistry, and the biological sciences as taught in most secondary schools represents much obsolete material and, what is even more important, a point of view that fails to represent modern attitudes. The basic concepts of these sciences have been altered beyond recognition and whole new fields, unknown a few years ago, are now areas in which important and active contributions to knowledge are being made.

Two consequences of this failure of science instruction in the primary and secondary schools to keep pace with the growth of knowledge have been a conspicuous lack of interest in science and mathematics in the part of students and a seriously inadequate preparation for more advanced study in colleges and universities. The quality of

the scientific training given our young people has so vital a role for the safety and economic welfare of this country that it can no longer be neglected if America is to maintain its position of leadership in science and technology.

The seriousness of the situation has led a number of eminent scientists to make a thorough and critical reexamination of science programs in the public schools. The National Science Foundation has provided support for major studies of science curricula in the secondary schools in which the knowledge, judgment and experience of distinguished scientists and competent teachers have been welded together to produce new and imaginative approaches to science instruction.

Two such studies are now in progress, one in physics and the second is in mathematics. Preparation is underway for similar studies in other scientific disciplines. From these efforts will come new textbooks, new laboratory manuals, new laboratory apparatus, teacher's guides, motion picture films to enlarge and enrich lectures and laboratory work, supplementary monographs to extend the understanding of teachers and students and supplementary teaching aids.

It should be emphasized that these comprehensive studies have been cooperative efforts in which scientists have sought and obtained the cordial assistance of the professional educational organizations so that the knowledge and experience of both groups could be utilized in the development of new courses that are high in quality and rich in subject matter interest.

Supplementary teaching aids. It is the purpose of this program to assist in the development of imaginative instructional equipment and other devices that will help teachers to maintain the highest possible levels of quality in their science courses. Although it is our plan to bring assistance to all levels of instruction, primary emphasis is to be given at present to the work of the secondary schools.

Instruction in the sciences deals both with things that can be seen, handled, studied in detail and subjected to experimentation and with abstract theories and concepts. Effective teaching of the sciences, therefore, requires instruments, experimental equipment, charts, models, and many other aids to teaching. The use of motion picture films, for example, has added a new dimension to classroom teaching.

The Foundation has limited funds for the development of such aids to good teaching, and we hope to be able to assist in this way in lightening the burdens of teachers in these days of crowded classrooms and steadily rising enrollments.

Laboratory equipment is often expensive and beyond the reach of the modest budgets of small schools. There is much that can be done to develop new and imaginative equipment that can be built at low

cost by the student or the teacher and that will enrich understanding even more than the nicely finished instruments of the laboratory supply houses. We are interested in bringing support to promising efforts to accomplish these ends.

This has been an over-long and I'm afraid a sketchy presentation of the activities of the National Science Foundation in attempting to improve the quality of education. May I say too, that after a trip through the outer space of public life, I find this brief re-entry into the academic atmosphere comfortably smooth and marked by a lump-in-the-throat reaction of delight in coming home to a familiar setting.

NSTA CONVENTION

The seventh annual Convention of the National Science Teachers Association will be held at the Ambassador Hotel in Atlantic City, New Jersey from March 31–April 4, 1959. The theme of this year's convention is "Science Education for America: An appraisal and a Look Ahead." Special features of the convention will include: elementary science workshops; demonstrations of teaching by "live" teachers; student demonstrations; "Here's How I Do It" sessions; exhibits; and discussion groups. This looks like a fine program, and all interested science teachers are urged to attend.

NEW THEORY SAYS LIQUID IS ORGANIZED IRREGULARLY

We know why a solid is a solid, and a gas is a gas. There are theories that account for them. In solids, the molecules are packed regularly; in gases, they move freely at random.

But why is a liquid a liquid? There is no satisfactory theory in terms of molecular structure which can tell us why.

Previous approaches have either treated a liquid as a solid with imperfections, or as a gas which is crowded up. Few have attempted to treat a liquid as a unique structure.

Now, Prof. J. D. Bernal, F.R.S., crystallographer and head of the physics department at Birkbeck College, University of London, has developed a theory stating that the secret of the structure of liquids is organized irregularity. The molecules are coherently packed, but without any regularity.

The great problem has been to demonstrate this in a physical model, and to explain this model in mathematical terms.

He has attempted to construct by hand, using table tennis balls or plasticine, a physical model of organized irregularity.

He has also had to develop his own statistical geometry to make this mathematical model. Mathematicians have been unable to provide him with any short-cut formulae.

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Robert Fertig

Burlingame High School, Burlingame, California

The AREA concept.

Many an engineering or science formula involving a *product* ($y=\bar{y}'\cdot\Delta_x$, $a\geq x\geq b$) can be evaluated by graphing y', then calculating the *area* y under its "curve" and bounded by the range of the independent variable.

WORK = average force times distance	$W=\bar{F}\cdot s$
MOMENTUM = average force times velocity	$\mu=\bar{F}\cdot v$
VOLUME = average section area times height	$V=\bar{A}\cdot h$
REVENUE = average selling price times number of items	$R=\bar{p}\cdot n$
ANNUAL INCOME = average principle times rate	$I=\bar{P}\cdot r$
DISTANCE = average velocity times time	$s=\bar{v}\cdot t$
VELOCITY = average acceleration times time	$v=\bar{a}\cdot t$

Case A) Dependent variable CONSTANT: $y'=c$:

Illus 1) The velocity of a car is constantly $\bar{v}=50$ ft./sec. (approximately 34 mi./hr.). Calculate the distance traveled from time $t=3$ sec. to $t=12$ sec. (See fig. 1). Solution:

$$s_3^{12}=\bar{v}\ t=50\ (\text{ft./sec.})\cdot(12-3)(\text{sec.});\ s=450\ \text{ft.}$$

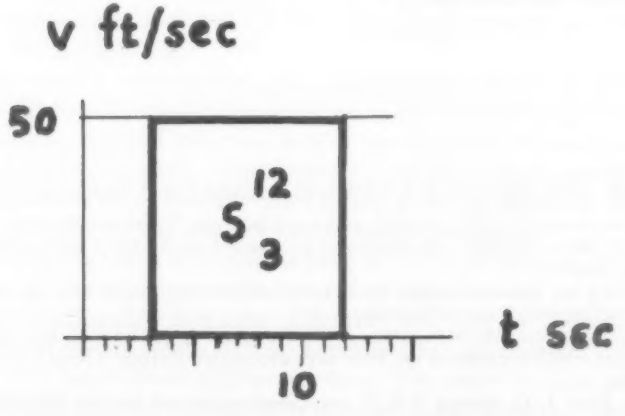

FIG. 1

Illus 2) The force used in pushing a car is constantly $F=200$ lb. Calculate the total work done in moving the car from $s=20$ ft. to $s=80$ ft. Graph and verify:

$$W_{20}^{80}=12{,}000\ \text{ft. lb.}$$

Illus 3) The average thrust developed by a rocket was $\overline{F}=10{,}000$ lb. during the period when its velocity changed from $v=100$ ft./sec. to $v=120$ ft./sec. Calculate the momentum developed during this period. Graph and verify:

$$\mathfrak{M}_{100}^{120}=200{,}000 \text{ lb. ft./sec.}$$

Illus 4) The selling price $\bar{p}$ is 20 \$/toaster. Calculate the total revenue from sales during the interval when the sales rose from $n=15$ toasters to $n=50$ toasters. Graph and verify:

$$R_{15}^{50}=700\$.$$

OBSERVATION: In each of the four illustrations the answer could have been obtained by calculating the AREA (above the horizontal axis, below the graph and between the vertical limits).

Case B) Dependent variable varies LINEARLY: $y'=kx+c$:

Illus 5) The force F required to stretch a spring s inches beyond its normal length varies linearly as shown in fig. 2. Calculate the work done in stretching it from an elongation $s=2$ in. to one of $s=5$ in. Solution: $F(2)=36$ lb.; $F(5)=90$ lb.; $\overline{F}=63$ lb., why?

$$W_2^5=\overline{F}\cdot s=63 \text{ lb.}\cdot(5-2) \text{ in.}=189 \text{ lb. in.}$$

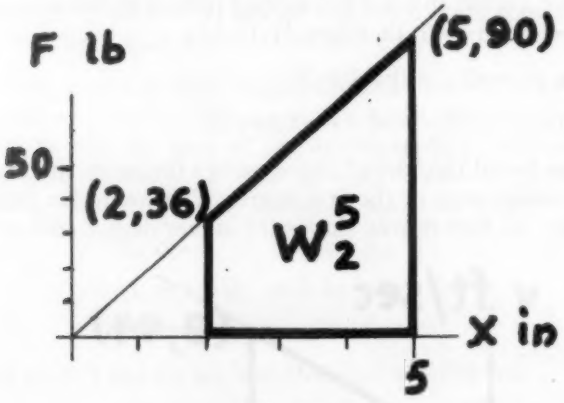

FIG. 2

Illus 6) In a running start, the initial (time zero) speed of a car was $v(0)=20$ ft./sec.; $v(8)=44$ ft./sec. (See fig. 3). Calculate the distance s traveled from time $t=3$ sec. to $t=7$ sec. Graph and verify: $v(7)=41$; $v(3)=29$; $\bar{v}=35$; therefore

$$s_3^7=35(7-3)=140 \text{ (ft).}$$

Illus 7) When the selling price p of an item is high, the possible number of sales n is few; when p is low, the possible number of sales is high. Assume p varies linearly; $p(1{,}000)=23$ \$/tire and $p(5{,}000)=15$ \$/tire. Calculate the total revenue R as the number of sales increases from $n=1{,}000$ tires to $n=3{,}000$ tires. Graph and verify that the average price in the range specified is $\bar{p}=21$ \$/tire, and $R=42{,}000$ \$.

Use the phrases, "the average of the lengths of the parallel bases," and "the perpendicular distances between the parallels" and rewrite the arithmetic formula for the area of a trapezoid.

OBSERVATION: The answers to illustrations 5, 6, and 7 can also be found by calculating the trapezoidal AREAS. Verify the geometry and algebra.

Case C) Dependent variable NOT linear: When the graph of y' is not linear, the only procedure for determining y may be to $\sum$(sum) a succession of small areas (usually trapezoidal), i.e.: $y=\sum y' \cdot \Delta_x$

(When we let $\Delta_x \to 0$, we usually write: $\Delta y = \int y' d_x$.)

CURVE-FITTING, data linear: To write the equation of a line, determine k and c for $y=kx+c$. Rule: "If a point is on a curve, then its coordinates 'satisfy' the equation of the curve."

Illus 8) In #5 assume $F=ks+c$. Determine k and c. Solution: (5, 90) $90=k\cdot 5+c$; (2, 36) $36=k\cdot 2+c$; solving these simultaneous equations we get $k=18$ and $c=0$; therefore $F(s)=18s$.

Illus 9) In #6 verify: $v(t)=3t+20$.

Illus 10) In #7 verify: $p(n)=-.002n+25$.

We have found the "area" under curves (between specified limits) whose equations were of the first degree. Can we derive formulas for areas under (a) first degree curves (b) higher degree curves?

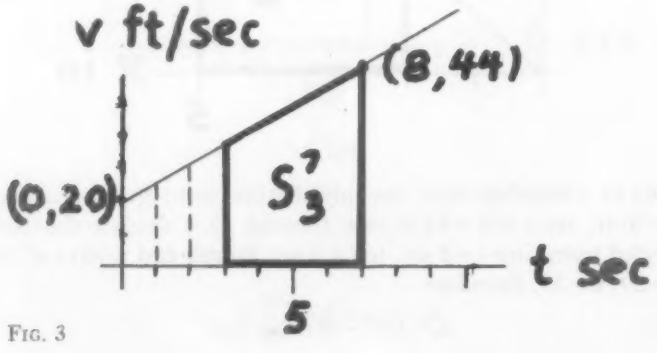

FIG. 3

Illus 11) Let's have another look at #6 and #9, where we have found $s'(t)=v(t)=3t+20$. Observe: $v(0)=20$, $v(1)=23$, $v(2)=26$, etc. Assume we know that the car was at the 0 ft. marker when the time was 0 sec $s(0)=0$.* Also let $\Delta_t=1$ sec. (see fig. 3).

time	$\Delta_s=\bar{v}\cdot\Delta_t$	$s_0{}^t=\sum_0^t \bar{v}\cdot\Delta_t$
0—1:	$\Delta_s=21.5\cdot 1=21.5$	$s_0{}^1=21.5$ ft.
1—2:	$\Delta_s=24.5\cdot 1=24.5$	$s_0{}^2=21.5+24.5=46.0$ ft.
2—3:	$\Delta_s=27.5\cdot 1=27.5$	$s_0{}^3=46.0+27.5=73.5$ ft.
		verify: $s_0{}^4=$ $=104.0$ ft.

Graph $s(t)$. Assume: $s(t)=at^2+bt+c$

Since

$$\begin{aligned} t=0,\ s=0: &\quad 0=\ 0\ +0\ +c,\\ t=2,\ s=46: &\quad 46=\ 4a+2b+0\\ t=4,\ s=104: &\quad 104=16a+4b+0 \end{aligned}$$

we get $c=0$.

Solve these simultaneous equations and verify: $s(t)=1.5t^2+20t$.

Reviewing #7: If no articles are for sale, then there is no Revenue, i.e.: $R(0)=0$. Verify that $R(n)=-.001n^2+25n$.

Illus 12) Given $y'(x)=kx+m$. Obtain a,b, and c for $y(x)=ax^2+bx+c$. Solution: Observe that $y'(0)=m$, $y'(1)=k+m$, and $y'(2)=2k+m$. If $y_0{}^1=y(1)$ equals the area of the corresponding trapezoid, then $y(1)=(m+m+k)/2=m+.5k$. Also $y_0{}^2=y(2)=2m+2k$ (verify). Assume $y(0)=0$. Substitute these values in $y(x)=ax^2+bx+c$

$$\begin{aligned} &(0,\ 0) && 0=0+0+c\\ &(1,\ m+.5k) && m+.5k=a+b\\ &(2,\ 2m+2k): && 2m+2k=4a+2b. \end{aligned}$$

Verify that $a=k/2$ and $b=m$;. also that $y(x)=\frac{1}{2}kx^2+mx$.

In higher mathematics it can be verified that if $y'(x)=k_1x^{n_1}+k_2x^{n_2}$, then

$$y(x)=\frac{kx^{n_1+1}}{n_1+1}+\frac{kx^{n_2+1}}{n_2+1}+c$$

* If the car was at the 10 ft. marker when $t=0$, then $s(0)=10$. Verify that $s(t)=1.5t^2+20t+10$.

where c is determined by the initial conditions, or other known values. (If y' is a polynomial of degree n, y is a polynomial of degree $n+1$.) In the very special case of illustrations 1, 6, 9, 11,

$s(t)$ is the distance formula,
$s'(t)=v(t)$ is the velocity formula,
$s''(t)=v'(t)=a(t)$ is the acceleration formula,
$s'''(t)=v''(t)=a'(t)=j(t)$ is the jerk formula.

Illus 1) $s'(t)=50t^0$; here $k=50$, $n=0$, so

$$s=\frac{50t^{0+1}}{0+1}+c=50t+c.$$

Illus 5) $W'(s)=18s$; here $k=18$, $n=1$, so $W=9s^2+c$.

Illus 6) $s'(t)=3t^1+20t^0$; here $k_1=3$, $n_1=1$, $k_2=20$, $n_2=0$, so

$$s=1.5t^2+20t+c.$$

Illus 7) $R'(n)=-.002n+25$; use rule and verify:

$$R(n)=-.001n^2+25n+c.$$

LIMITS: In illustration 6, the distance traveled from $t=3$ to $t=7$ is

$$s_3^7=s(7)-s(3)=[1.5(7)^2+20(7)]-[1.5(3)^2+20(3)]=140 \text{ ft.}$$

Illus 7) Similarly verify

$$R_{1,000}^{3,000}=42,000 \text{ \$.}$$

Note: equations can not always be obtained for curved $y'(x)$; nor can $y'(x)$ always be summed by formulas into $y(x)$. In such cases select Δ_x consistent with the desired accuracy. Use the method of illustration 11 and proceed, or use the following trapezoidal method.

TRAPEZOIDAL METHOD for approximating area under a curve. Use illus 6. Given: $s'(t)=3t+20$; select $\Delta_t=.5$ sec. and a number of trapezoids=8. Solution:

$$s_3^7=\frac{7-3}{8}\left[\tfrac{1}{2}v(3.0)+v(3.5)+v(5.0)+\cdots+v(6.0)+v(6.5)+\tfrac{1}{2}v(7.0)\right]$$

$$=.5\cdot[14.5+30.5+(\text{you complete})]=140 \text{ ft.}$$

The area under a curve can also be found by means of a planimeter. Weighing is another method that can be used. Often $y'(x)$ can be approximated by some series.

CAM DESIGN

Preliminary requirements might specify only a certain lift $s=4$ (inches) in a given time $=3$ (seconds). The design engineer could further assume that the initial conditions were: when $t=0$, $s=0$, and $v=0$; also that the final a vs. t graph would be shaped like the trapezoid $OABC$; O: (O, O), A: (1, 6), B: (2, 6), C: (3, 0). (Since high acceleration produces high stress and consequent wear or failure, and other poor acceleration characteristics produce "jerk," the acceleration curve should be a smooth curve rather than the trapezoid mentioned.)

Verify then graph each of the following equations through its valid range:

1) $0\leq t\leq 1$: $a(t)=6t$; $t=0$, $v=0$: $v(t)=3t^2$; $t=0$, $s=0$: $s(t)=t^3$

2) $1\leq t\leq 2$: $a(t)=6$; $t=1$, $v=3$: $v(t)=6t-3$; $t=1$, $s=1$:

$$s(t)=3t^2-3t+1$$

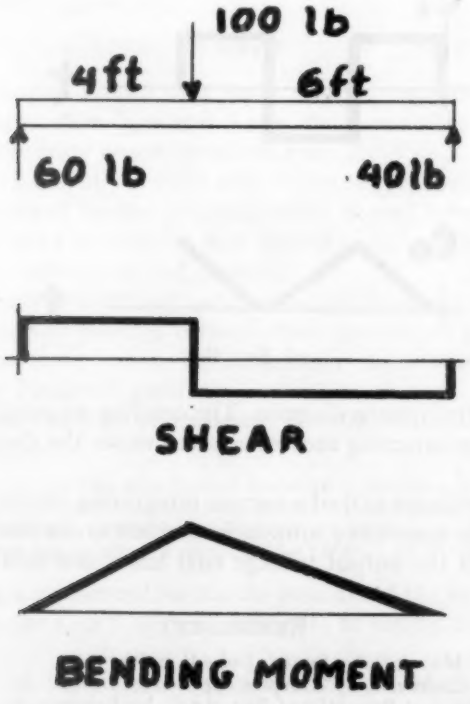

FIG. 4a

3) $2 \leq t \leq 3$: $a(t) = -6t + 18$; $t = 2$, $v = 9$: $v(t) = -3t^2 + 18t - 15$;

$t = 2$, $s = 7$: $s(t) = -t^3 + 9t^2 - 15t + 9$.

Problem) The specifications were $s(3) = 4$. The engineer would modify his original equations: $a(t) = kt$, $a = k$, $a = -kt + 3k$. Verify that the final displacement equation is

$$s(t) = -kt^3/6 + 3kt^2/2 - 5kt/2 + 3k/2.$$

Since s is to be 4 inches when t is 3 seconds, then $k = 4/3$. Rewrite each of the $s(t)$ equations using this value.

Other APPLICATIONS: A beam loaded with a single concentrated

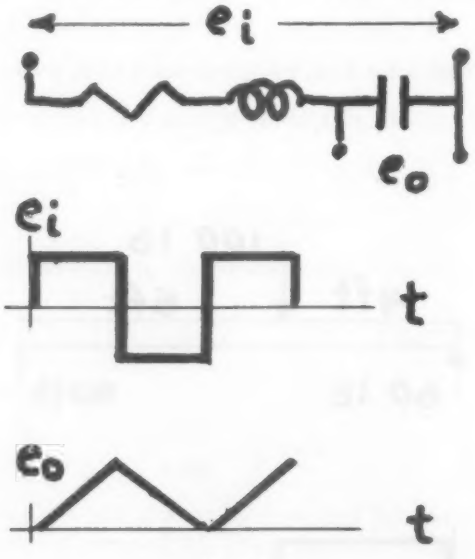

FIG. 4b

load has a certain shear diagram. The bending moment diagram can be obtained by summing successive areas under the shear curve. (See fig. 4a.)

The input voltage $e_i(t)$ of a certain integrating circuit has a square wave-form. By successive summations of the areas under $e_i(t)$ it can be shown that the output voltage $e_0(t)$ has a saw-tooth wave-form. (See fig. 4b.)

REFERENCES

1. *Resistance of Materials*, by SEELY, 2nd ed., p. 90.
2. *Calculus for Electronics*, by RICHMOND, p. 131.
3. *Math. and Physical Principles of Eng. Anal.*, by JOHNSON, p. 76
4. *The Engineer's Manual* (1917) by HUDSON, p. 119.

Eggs and Physics—A Class Experiment

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Part II

The Moments of Inertia of Hens' Eggs

Perhaps the students have, in their mechanics classes, begun to study moments of inertia. The measurement of the moments of inertia of eggs adds variation to the foregoing experiments.

(14) *Definition of Moment of Inertia*

If a particle of mass m is at a distance r from a given axis, its moment of inertia about that axis is defined by:

$$i = mr^2$$

A finite body of mass M may be supposed made up of particle masses m_1, m_2, $m_3 \cdots$ and if these are at distances r_1, r_2, $r_3 \cdots$ respectively from the given axes, the moment of inertia of the body about that axis is given by:

$$I = m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + \cdots = \sum (mr)^2$$

The moment of inertia of a body is often expressed as $I = Mk^2$. Here, of course, $M = \sum m$ and k is a distance called the *Radius of Gyration* of the body about the given axis.

The terms moment of inertia and radius of gyration are traditional terms. Moment of inertia is better called *Second moment* for just as the product $m \times r$ is called a first moment, the product $m \times r \times r$ is conveniently called a second moment.

The moments of inertia of bodies of simple geometrical shape about axes of symmetry passing through their centers of gravity can be calculated, in some cases, by elementary mathematics and more easily by the Integral Calculus.

Some simple cases are given below. Here M is the mass of the body and R the radius.

(a) A thin ring about an axis through its centre $\perp$ its plane. $I = MR^2$ i.e. $k^2 = R^2$
(b) A uniform circular cylinder about its cylindric axis $I = MR^2/2$ i.e. $k^2 = R^2/2$
(c) A thin spherical shell about a diameter $I = 2MR^2/3$ i.e. $k^2 = 2R^2/3$
(d) A uniform sphere about a diameter $I = 2MR^2/5$ i.e. $k^2 = 2R^2/5$

In quoting a moment of inertia the position of the axis must always be stated. In the C.G.S. system, moments of inertia are expressed in gm.cm^2.

Moments of Inertia are very important in Mechanics. For example the kinetic energy of a flywheel rotating on fixed bearings is

$\frac{1}{2}I\Omega^2$ where I = the moment of inertia of the wheel about the axis of rotation and Ω is the angular velocity of the wheel expressed in radians per second. Note that the simple formula for the kinetic energy of a moving body i.e. K.E. $= \frac{1}{2}MV^2$ could not be used here without some modification.

Just as the mass or inertia of a body may be considered as a measure of the resistance the body offers to being linearly accelerated by a force acting on it, and is expressed quantitatively as

$$\text{mass of body} = \frac{\text{acting force}}{\text{acceleration produced}}$$

so the moment of inertia of a body about an axis may be considered as a measure of the resistance the body offers to being rotationally accelerated about that axis by a twist (or torque or couple) acting on it and is expressed quantitatively as

$$\text{moment of inertia of body about the axis} = \frac{\text{moment of twist (or torque)}}{\text{angular acceleration produced}}$$

Other examples of the use of moment of inertia occur in the study of Tops and Gyroscopes, the Bending of Beams, the Torsion of Wires. In Modern Physics the moments of inertia of molecules, atoms and nucleons play an important part in the theories of their spectra.

(15) *Comparison of the Moments of Inertia of Simple Bodies*

The easiest way to compare moments of inertia of simple symmetrical bodies is to use a Torsion pendulum provided with a frame for holding the body.

A simple form of this apparatus is shown in Fig. 3. A circular base plate P is supported by two rods R, R from a cross rod C which in turn is supported by a fine wire W from a fixed support S. It is convenient for P to have a control hole so that rounded bodies B, such as balls and eggs, may be placed ln P with their centers of gravity below the axis of the wire.

If the frame be twisted away from its position of rest and released it vibrates to and fro under the elastic forces of torsion in the wire. The motion is very nearly simple harmonic motion and the period of vibration is given by:

$$T_0 = 2\pi\sqrt{\frac{I_0}{C}}$$

where I_0 = Moment of inertia of the frame about the axis of vibration and C = the couple constant of the wire.

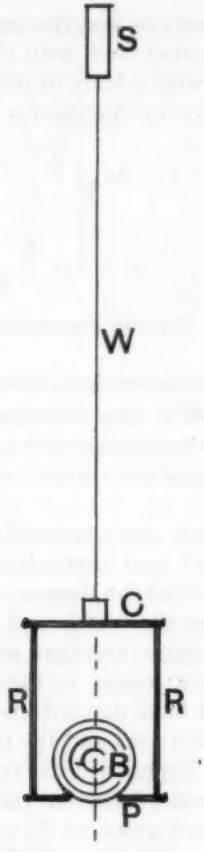

FIG. 3. The torsion pendulum with frame for the comparison of the moments of inertia of bodies.

If now a body of moment of inertia I about its central axis be placed on P the period of vibration changes to T where T is given by

$$T=2\pi\sqrt{\frac{I_0+I}{C}}$$

whence by elimination of C we get

$$\frac{T^2}{T_0^2}=\frac{I_0+I}{I_0} \text{ or } I_0=I\,\frac{T_0^2}{T^2-T_0^2}$$

If I is calculable this equation enables us to find the I_0 of the frame. A steel ball bearing is suitable body for this calibration for its I about a diameter $=\frac{2}{5}MR^2$.

Now that I_0 is known we can find the moments of inertia of other bodies if they can be mounted on P with their centers of gravity on the central axis. Suppose with a body of unknown moment of inertia I_1 about this axis the period of vibration is T_1. Then

$$T_1 = 2\pi\sqrt{\frac{I_1+I_0}{C}}$$

whence

$$\frac{T_1^2}{T_0^2} = \frac{I_0+I_1}{I_0} \text{ or } I_1 = I_0\,\frac{T_1^2-T_0^2}{T_0^2}$$

(16) *Hints on the Use of a Torsion Pendulum Provided with an Inertia Frame*

It is well to start all observations from about the same initial angular amplitude (say 90°). The vibrations usually continue for a long time and they are isoschronous over a large range of angle thus differing from a simple pendulum whose vibrations are isochronous over only a small range.

Obtain a good stop-watch, make yourself familiar with the starting and stopping arrangement and then check it, for say 5 minutes, against a standard clock. Find the time occcupied by 20 (or 30 or 50) complete vibrations. Start the watch and say "Nought" when the frame passes through a central position, say from right to left, and continue counting at every transit in the same direction until the number of vibrations you have decided upon are completed. Record at once the number of vibrations and the time by the watch. Divide by the number to get T_0. Repeat at least twice and perhaps more depending upon the agreement between your separate values of T_0. Finally calculate the Mean value of T_0 and if you can append to it the average deviation (a.d.) so much the better. Thus $T_0=0.712$ a.d. 0.001 sec. tells a reader much more than just $T_0=0.712$ sec.

If only an ordinary watch or clock is available, two observers should combine, one to watch the pendulum and count the vibrations, the other to observe the clock and to record the times. A convenient method to use is the *Half Table Method* where the first observer decides to call out sharply (but not loudly) the instant of the transit at the 0th, 5th, 10th $\cdots$ transits up to say 35 and the second observers notes these instants in hours, minutes, seconds as in this Table. The mean of the times in the last column on being divided by 20 should give a good value of the period of vibration.

The table may be abridged or enlarged according to wish. It is well to record the hours as well as the minutes and seconds as this tells you later on at what time of the day the experiment was made. An advantage of the Half Table method is that it keeps two observers alert all the time.

The procedure is the same when a body is placed on the frame.

Transit	Time			Transit	Time			Total times of 20 vibrations seconds
	h	*m*	*s*		*h*	*m*	*s*	
0	—	—	—	20	—	—	—	—
5	—	—	—	25	—	—	—	—
10	—	—	—	30	—	—	—	—
15	—	—	—	35	—	—	—	—
							Arithmetic Mean	—

(17) *Details of a Convenient Inertia-Frame and Its Calibration and Use*

I give more numerical details here of my own apparatus as the experiment may be new to the class. The frame (Fig. 3) has a base plate P of brass of diameter 6.3 cm. and thickness 0.2 cm. The central hole is 2.5 cm. in diameter. The rods RR are 3 mm. in diameter, 7.2 cm. long and about 5.4 cm. apart. The wire W is made of phosphor bronze. It is 25.8 cm. long and 0.0585 cm. in diameter.

The frame alone has a period of $T_0 = 0.712$ a.d. .001 sec. When a steel ball-bearing of mass 225.5 gm. and of diameter 3.810 cm. ($= 1\frac{1}{2}''$) is placed upon the frame the period becomes 1.094 a.d. 0.001 sec.

The I of the ball about its diameter $= \frac{2}{5} \times 225.5 \times 1.905^2 = 327.3$ gm.cm.^{2} hence

$$\frac{1.094^2}{0.712^2} = \frac{I_0 + 327.3}{I_0}$$

whence

$$I_0 = 327.3 \times \frac{0.507}{0.690} = 240(.5) \text{ gm.cm}^2.$$

We are now ready to measure the moments of inertia of eggs and egg shells. Tables of Squares of Numbers are useful in cutting down the arithmetical labor.

(18) *Moment of Inertia of a Symmetrical Egg Shell*

Blow such an egg and let is stand for a while to drain and partially dry. As the shell has little moment of inertia the timing must be *very* carefully done. Repeat several times and take the means.

Such a shell had a mass of 7.69 gm. a length of 6.08 cm. and a breadth of 4.26 cm. It looked nearly a prolate spheroid; let a, b = equal the major and minor semi-axes respectively, i.e. $a = 3.04$ cm., $b = 2.13$ cm.

Placed on frame with long axis vertical the mean $T_a = 0.747$ sec. whence

$$I_a = 24.1 \text{ gm.cm.}^2 \text{ and } k_a^2 = 24.1/7.69 = 3.13 \text{ cm.}^2.$$

Placed on frame with long axis horizontal the mean $T_b = 0.760$ sec. whence

$$I_b = 33.6 \text{ gm.cm}^2. \text{ and } k_b^2 = 33.6/7.69 = 4.37 \text{ cm.}^2.$$

What does Mathematics give for the values of k^2? This depends on the assumptions made for the thickness of the shell.

(1) Assume the thickness at the ends of the axes to be proportional to the lengths of the axes. Then

$$k_a^2 = \frac{2}{3} b^2 \quad \text{and} \quad k_b^2 = \frac{1}{3}(a^2 + b^2).$$

(2) Assume the thickness to be the same at the ends of the axes. Then

$$k_a^2 = \frac{2}{5} b^2 \frac{b + 4a}{b + 2a}$$

and

$$k_b^2 = \frac{1}{5} \frac{b^3 + 4b^2a + 3ba^2 + 2a^3}{b + 2a}$$

(3) Assume the thickness to be the same everywhere. Then the values of k^2 are given by very complicated expressions and I do not quote them.

Applied to this shell, assumption (1) gives $k_a^2 = 3.03$ cm.^{2} and $k_b^2 = 4.59$ cm.^{2}, assumption (2) gives $k_a^2 = 3.16$ cm.^{2} and $k_b^2 = 4.38$ cm.^{2} and assumption (3) gives $k_a^2 = 3.09$ cm.^{2} The agreement with experiment is fair.

(19) *Moments of Inertia of the Whole Egg*

I describe the experiment with the fresh egg first and that with the hard-boiled egg second for although the latter is the easier once the egg is boiled it cannot be unboiled. This is an instance where experience with other eggs helps.

(1) *The fresh egg.* Weigh the egg. Place it carefully on the frame with long axis vertical. Start the vibrations with amplitude of at least 90°. You will find that the vibrations quickly die away due to internal friction of the liquid contents with one another and with the shell. The vibrations are said to be "damped." Perhaps only 10 vibrations are timeable so do the best you can and repeat. Now place

the egg with the long axis horizontal and repeat the timing. In this case you will find that the damping is even greater than before, (explain why) and perhaps only 5 vibrations are timeable Here again we see the effect of internal friction.

In one experiment with a long and fairly symmetrical egg of mass 61.3 gm., length 6.16 cm., breadth 4.19 cm., I found

$$T_a = 0.75 \text{ sec. whence } I_a = 26 \text{ gm.cm.}^2$$

$$T_b = 0.83 \text{ sec. whence } I_b = 86 \text{ gm.cm.}^2$$

(2) *The hard boiled egg.* Boil for 10 minutes. Cool. Weigh again. Repeat the timing in both positions. The vibrations last a long time now for the contents of the egg are solid and there is no damping due to interior friction. For the same egg as in (1) I found mass = 61.4 gm. length and breadth as before and

$$T_a = 0.864 \text{ sec. whence } I_a = 113 \text{ gm.cm.}^2$$

and

$$T_b = 0.939 \text{ sec. whence } I_b = 177 \text{ gm.cm.}^2$$

(3) Remove the shell carefully and weigh it. By subtraction or direct experiment get the weight of the solid interior. It is now possible to check that the I of whole hardboiled egg = I of shell + I of the solid interior. Thus with the same egg I found mass of shell = 6.5 gm. hence by the equations given above for the shell, I_a and I_b of shell = approximately 20 and 29 gm.cm.^{2} respectively. Whence by subtraction the I_a and I_b of the interior = 93 and 148 gm.cm.^{2} respectively. This could be checked directly by timing the interior on the frame. However the interior is of fairly uniform density so we can calculate the I's by using the formulas for a solid prolate spheroid, viz. $k_a^2 = \frac{2}{5}b^2$ and $k_b^2 = \frac{1}{5}(a^2+b^2)$. On substitution we find for the interior:

$$I_a = (61.4-6.5)\frac{2}{5}(2.07)^2 = 94+ \text{gm.cm.}^2$$

and

$$I_b = (61.4-6.5)\frac{1}{5}(2.07^2+3.06^2) = 149 \text{ gm.cm.}^2.$$

The agreement is good.

(20) *Summary of Results of the Moments of Inertia* of 16 fresh hens' eggs (Grade A on the market).

Shell alone

$$I_a = 20\tfrac{1}{2} \text{ a.d. } 2 \text{ gm.cm.}^2$$

$$I_b = 29\tfrac{1}{2} \text{ a.d. } 2 \text{ gm.cm.}^2$$

Unboiled Egg

$$I_a = 34 \text{ a.d. } 4 \text{ gm.cm.}^2$$

$$I_b = 92 \text{ a.d. } 24 \text{ gm.cm.}^2$$

Hard Boiled Egg

$$I_a = 125 \text{ a.d. } 10 \text{ gm.cm.}^2$$

$$I_b = 168 \text{ a.d. } 20 \text{ gm.cm.}^2$$

The average duration is the average of the individual deviations from the mean value and it is quite possible that some deviations may be several times the a.d.

We have now had many moments of Energetics and may now take a rest and consume the eggs that are left over. Finally clean up all the apparatus and leave the benches clean and tidy. Write up your report concisely and intelligibly, with diagrams.

CAMERA WORKS WITHOUT LIGHT

A camera-like device that requires no light to take pictures depends solely on thermal or infrared radiation from the person or object on which it is focused. Known as a Thermograph, it collects this radiation by a scanning optical system and focuses it onto an infrared detector. The resulting electrical signal is compared to a preset reference level. Deviations above the reference level are amplified and modulate the light output of a glow tube, which forms a thermal image of the scene on photographic film in a Polaroid Land camera for quick developing. Development of the device was under sponsorship of the U. S. Army Engineer Research and Development Laboratories.

PROPOSE NUCLEAR REACTOR TO STERILIZE FARM LAND

Two scientists at the University of California at Los Angeles have proposed a portable nuclear reactor for sterilizing agricultural land. Such a reactor may prove to be a practical, economical means of treating soil prior to planting.

Gamma rays and neutrons from the reactor bombarding the soil would kill and prevent reproduction of such parasites as nematodes, fungi and insects which afflict crop plants and reduce yields, as well as prevent the germination of weed seeds.

They said that since the portable reactor would be operating (probably by remote control) in relatively unpopulated areas, unwieldy shielding could be reduced substantially.

Thus it would probably be of much simpler design than stationary ones. Any radioactivity induced in the soil would be short-lived enough not to constitute a hazard either in the soil or in crops grown in it.

The portable reactor should be designed to move at about six or seven miles per hour, irradiating 100 square feet of soil per second to a depth of six inches.

The UCLA scientists estimated that the reactor could be designed to be used in field treatment at a cost of about $70 an acre. Compared to the present $300 to $500 per acre it costs for chemical sterilization, the economic advantages are obvious.

Recommendation for the Preparation of High School Teachers of Science and Mathematics—1959

A Report of the Sub-Committee on Teacher Certification—the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the and Advancement of Science*

Alfred B. Garrett, *Chairman*

The Ohio State, University, Columbus, Ohio

The concern for better preparation for teaching in the field of science and mathematics (hereafter referred to in this report as the sciences) has been growing during the last several years. Very recently this concern has been intensified considerably as the result of new developments both nationally and internationally. A statement was made by the Cooperative Committtee of the AAAS in 1946 with reference to recommended minima for the preparation of science teachers in content material.[1] In that same report a general statement was given with reference to the breadth of preparation that was to be desired.[2]

I. Purpose. It seems that it is now time (1) to re-examine our original statements, (2) to take cognizance of the impact of those events that have transpired in the last ten years on the requirements for the preparation of science teachers and (3) to make additional recommendations which result from the demands of the changing circumstances.

It is well recognized that changes in state certification laws may not always be made quickly. It is our hope, however, that this information and these recommendations, even though not immediately written into certification codes, will be studied by college and university departments of education, teachers colleges, state departments of education, certification bureaus and accrediting agencies, school ad-

* Committee Members: Wayne Taylor, University of Texas; Henry W. Syer, Kent School; S. Winston Cram, Kansas State Teachers College; Fred Dutton, Michigan State University; Harold Wise, University of Nebraska; Bro. G. Nicholas, La Salle College; Robert Stollberg, San Francisco State College.

[1] School Science and Mathematics, February 1946.

[2] *The recommendations are:*

1. A policy of certification in closely related subjects within the broad area of science and mathematics should be established and put into practice.
2. Approximately one-half of the prospective teacher's four-year program should be devoted to courses in science.
3. Certification to teach general science at the 7th, 8th, and 9th grade level should be granted on the basis of a broad preparation including college courses in all the subjects concerned in general science.
4. Colleges and certification authorities should work toward a five-year program for the peparation of high school teachers.
5. Curriculum improvements in the small high schools should go hand in hand with improvement in teacher preparation.

ministrators who select science teachers, colleagues in subject matter areas, and finally by those students and teachers who are preparing to do a more effective job in teaching science in our secondary schools.

II. New developments to be considered. Several important factors have influenced the type of recommendation we now make on the course content that prospective teachers should have.

1. *The rapid changes that have occurred in a number of the sciences in the last decade.* Chemistry, physics, biology, astronomy, meteorology, mathematics, and geology have all advanced considerably in the last ten years. Word of new advances spreads by newspapers, magazines, public lectures, and television. This stimulates the curiosity of students who then seek answers to many questions. Teachers must be prepared to stimulate further the interest in such questions, to provide sound answers for them, and to direct effective reading at the level of the student's background. The course work taken by the teachers should prepare them to keep abreast of the new developments which are often highly complex, to answer questions about them, and to direct discussion of them.
2. *College entrance with advanced standing.*[3] A concerted move was made (beginning in 1954) by a number of the fine colleges and universities of this country to work with secondary schools in developing college-level courses for their most able students. In the resulting program, for example, mathematics starting in the 10th grade leads to Calculus in the 12th. In chemistry, the time-equivalent of at least three semesters permits instruction at the college-level using college texts. Thus students qualify for sophomore courses on college entrance thereby reducing duplication. In physics similar programs have been available, but unless Calculus is also taken, the policy has been to recommend the advanced mathematics instead of advanced physics, thus making it possible for the student to start his sophomore physics (using Calculus) during the freshman year in college. Similar programs have been in effect in biology, English, languages, and history. This program, expressing confidence in our secondary schools, lays emphasis on the results of good teaching in high school which in turn may be rewarded by credit toward college graduation, or time for more advanced work in college. This reward is made on the basis of the college level course programs referred to above and on examinations prepared and graded by committees of school and college teachers. Selected groups of college freshmen have taken the same examinations for use in setting grade standards. In 1954 candidates were examined from 18 schools (9 public, 9 private). In 1957 more than two hundred schools participated.
3. *Demonstrated proficiency vs. "16" credits.* More and more of the colleges and universities are emphasizing demonstrated proficiency in subject matter areas rather than simply permitting entrance to the college with "sixteen" high school credits or a certain number of academic units. More and more we find colleges over the country adopting some kind of entrance examination as part of the method of selecting their students.
4. *More content courses to meet the problems of complexity.* The increased complexity of the fields of science produces more impact upon the importance of content material to make it possible for the teacher to answer the "why" type of question rather than to just teach the material empirically.

There may be other factors but certainly these are some which should be recognized.

[3] Bulletin on Advanced Placement Program, College Entrance Examination Board, 425 W. 117 Street, New York, N. Y. Norton, Bayes. "College Admission with Advanced Standing"; *J. Chemical Education*, Vol. 33, pages 232–237 (1956).

III. Pertinent considerations. In formulating a set of recommendations for the training of high school teachers of science we are immediately confronted with several conflicting circumstances.

First: most science teachers are required to teach several sciences including, perhaps, a course in general science, rather than just one science. This means that a teacher must have depth of preparation in a variety of areas.

Second: because of the impact of science on other areas, the science teacher should have preparation in the social sciences and humanities to help give him the kind of perspective that we like the top-rate scholar and citizen to have.

Third: there are certain elements in professional education which should be helpful in giving the best performance in the classroom. These elements may be provided by courses in such areas as the psychology, philosophy, and methodology of education and especially by experience in student teaching.

The Problem. Our problem then, is (1) to recognize, in a very objective manner, the role of these several new developments in the last decade, (2) to recognize the problems that we face in building a realistic academic program for preparation of science teachers and (3) to make recommendations with reference to the best type of program that can be achieved to meet these changing needs.

The academic program to meet these three facets of our problem will certainly be a full one. However, assuming a minimum of 120 semester hours of academic work for graduation, these requirements may be met and still leave approximately one half of the student's academic program free for the humanities, social sciences, and professional educational courses. Many students can or will have more than 120 hours of academic credit. One half of the student's time for preparation in his teaching area seems reasonable to expect if he is to be properly prepared. Furthermore, this amount of concentration can give him such depth that it will be possible for him to build on it later with a fifth year or more of content material to further improve his competence in the science area.

In all of this planning to build a program to train science teachers it seems almost impossible to plan a satisfactory four year program to prepare teachers to teach in widely divergent areas: for example, English teachers to teach physics, or social science teachers to teach chemistry, or physical education teachers to teach mathematics. On the other hand, if multiple teaching assignments are necessary, some favorable combinations are physics and mathematics, chemistry and physics, and biology and health.

IV. Recommendations for each science area. The courses which are recommended in each teaching area, together with supporting courses,

are outlined in the following sections. Each course is designated in terms of semester hours of credit; this designation is intended only to indicate the general proportion of time and the minimum requirements.

The supporting courses which are recommended should be the basic courses in that science area, and not the survey courses, and should in each case include laboratory work.

The earth science course should contain, not only the elements of geology but also some topics relating to meteorology, physical geography and astronomy.

The description of each course in the following sections is merely suggestive or illustrative of the possible topics and makes no attempt to suggest all that could or should be included.

The committee realizes that the programs recommended here do not guarantee an inspiring teacher, but they should help.

PART 1. SUGGESTED COURSES IN BIOLOGY AND OTHER SCIENCES FOR THE PREPARATION OF HIGH SCHOOL TEACHERS OF BIOLOGY

(Given in semester hours)

Suggested Courses (See notes Below)	A	B	C	D	E	4-year total	5th year	5-year total
Biology	10	8	4	5	4	30	12	42
Chemistry						12	4	16
Physics						8	4	12
Earth Science						3	—	3
Mathematics						6	2	8
Totals						59	22	81

Notes on Part 1:

1. *Descriptions of Biology Courses*
   - A. *Principles of Biology.* Characteristics of living organisms, cell theory, structural system of plants and animals, metabolism, maintenance of individual, (health and disease).
   - B. *Plant and Animal Physiology and Anatomy.* Morphology, study of tissues, functional activities of cells and tissues, reflexes and tropisms, functional units of systems, catalysts, and enzymes.
   - C. *Ecology and Conservation.* Environment, soil, populations, relationships of species, distribution of communities. Field work should be an integral part of this course. This course could be coordinated with the work in Earth Sciences.
   - D. *Developmental Anatomy and Genetics.* Growth and development, principles of heredity, evolution.
   - E. *Preparation and Use of Biological Materials.* This course should be conducted by one conversant with the problems of biology teachers. Consideration must be given to teaching techniques peculiar to biology. Preparation and proper use of demonstration and laboratory materials, teaching aids and methods should be emphasized.

2. *Fifth Year*
   There should be a minimum of mandated semester hours in biology to permit more flexible selection of the courses which will be of most benefit to the teachers. "Cultural" courses in general science should be allowed (history of science, problems of atomic age, laboratory techniques in more than one science; *et al.*). However, 25% of this year should be devoted to definitely biological topics, such as radiation biology (see Physics courses), microbiology, taxonomy, and training in microtechnique. It is to be understood that more courses in biological sciences should be encouraged as electives.
3. *Description of Courses in Other Sciences Recommended for Biology Majors*
   Principles of inorganic and organic chemistry, particularly as it applies to living things. Laboratory work should be included. Biochemistry is recommended in the fifth year. Standard courses in physics, earth science, and mathematics are expected.

PART 2. SUGGESTED COURSES IN CHEMISTRY AND OTHER SCIENCES FOR HIGH SCHOOL TEACHERS OF CHEMISTRY

(Given in semester hours)

Suggested Courses (See Notes Below)	A	B	C	D	4-year total	5th year	5-year total
Chemistry	8	8	4	8	28	18	46
Physics					8	6	14
Biology					8		8
Earth Science					3		3
Mathematics					12	6	18
Totals					59	30	89

Notes on Part 2:

1. *Description of Chemistry Courses*
   A. *General Principles:* Composition and structure of matter, atomic and molecular theory, states and transitions of matter, stoichiometry, nature of solutions, periodic tables and relationships, rates of reactions and equilibrium, ionic equilibrium and properties of electrolytes, oxidation-reduction and electro-chemistry, energy relationships and colloidal state.
   B. *Organic:* Nomenclature, hydrocarbon series, functional groups and their basic reactions, typical methods of preparation, application.
   C. *Analytical:* Gravimetric and volumetric and instrumental methods and their applications and limitations.
   D. *Physical:* Determination of precise physical properties and the application of these data to problems of reaction rates, equilibrium systems and structure determinations.
2. *Fifth Year*
   For the fifth year the chemistry courses should include advanced inorganic chemistry, biochemistry, and radiochemistry.
   a) *Inorganic:* Relation of structure to properties, periodic system, typical reactions, and the application of physical chemical principles to inorganic systems.
   b) *Biochemistry:* Fundamental reaction systems of living organisms.
   c) *Radiochemistry:* General principles including some simple measurements.

3. *Supporting Courses*

The other supporting courses should be the basic courses in physics, biology, mathematics, and earth science.

PART 3. SUGGESTED COURSES IN PHYSICS AND OTHER SCIENCES FOR THE PREPARATION OF HIGH SCHOOL TEACHERS OF PHYSICS

(Given in semester hours)

Suggested Courses (See notes Below)	A	B	C	4-year total	5th year	5-year total
Physics	10	10	5	25	15	40
Chemistry				13	10	23
Biology				6		6
Earth Science				3		3
Mathematics				13	5	18
Totals				60	30	90

Notes on Part 3

1. *Description of physics courses.*
   A. *Introductory course in College Physics:* a course which covers the conventional areas of mechanics, sound, heat, electricity, magnetism, light and some aspects of modern physics. Problem work and laboratory experience should make up at least half of course activities.
   B. *A second year course in physics:* a composite of the advanced courses in heat, light and electricity especially planned for the needs of the secondary teacher of physics. Emphasis should be on a thorough treatment of a limited number of concepts and principles in these areas. Experiences should be provided in planning experimental demonstrations and laboratory work associated with these concepts and principles. The usual courses in advanced light, etc. may be substituted in the absence of such a course planned for teachers.
   C. *Modern Physics:* a course that covers the phenomena, concepts, and experimental techniques of modern atomic and nuclear physics using mathematics through Calculus. At least 25% of the course should be laboratory experience.
2. *Description of Chemistry Courses*
   Chemistry courses should include General Chemistry, Qualitative Analysis, Organic and/or Physical Chemistry.
3. *Description of the Other Science Courses*
   The mathematics courses should include Calculus. The Biology and Earth Science should be basic courses.

PART 4. SUGGESTED COURSES FOR THE TEACHER WHO IS PREPARING TO TEACH BOTH PHYSICS AND CHEMISTRY OR COURSES IN PHYSICAL SCIENCE

(Given in semester hours)

For many prospective teachers in the field of physical science, personal interests and potential teaching assignments include both physics and chemistry. The preparation of such teachers might well include a better balance between chemistry and physics than indicated in either Part 2 or Part 3 above. Such a "physical science" preparation is suggested in the table below.

	A	B	C	4-year total	5th year	5-year total
Physics	8	6	4	18	12	30
Chemistry				18	13	31
Biology				6		6
Earth Science				5		5
Mathematics				13	5	18
Totals				60	30	90

PART 5. SUGGESTED COURSES IH MATHEMATICS AND SCIENCE FOR HIGH SCHOOL TEACHERS OF MATHEMATICS

(Given in semester hours)

Suggested Courses	A	B	C	D	E	F	4-year total		5th year		5-year total	
							Math	Supporting Science	Math	Supporting Science	Math	Supporting Science
Teachers of Math only (Senior High School)	12	6	3	3	3	3	30	18	12	6	42	24
Teachers of Math only (Junior High School)	9	3	3	3	3	3	24	12	9	3	33	15
Teachers with Math minor, (Junior or Senior High School)	9	3	3			3	18					

Notes on Part 5:

1. *Teaching Area:* There are three teaching areas distinguished in this report:
   1. Mathematics in the senior high school.
   2. Mathematics in the junior high school.
   3. Mathematics combined with some other field such as science, history, or some other field at the junior or senior high level. Even though teaching assignments are not as desirable as those with only mathematics, such combinations must be recognized.
2. *Mathematics Courses:* On the undergraduate level minimum requirements in each section of mathematics are specified. On the graduate level, only the total additional number of hours in mathematics is specified.
   A. *Analysis:* Trigonometry, plane analytic geometry, Calculus (at least six semester hours required), solid analytic geometry, advanced Calculus, differential equations, infinite series.
   B. *Applications:* Mechanics (statics and dynamics), mathematical physics, astronomy (mathematical), actuarial mathematics (finite differences, interpolation, numerical analysis), uses in behavioral science (theory of gases, linear programing, operations research).
   C. *Probability and Statistics:* Emphasizing probability and statistical inference.
   D. *Algebra:* Abstract algebra (fields, rings, groups, linear algebra, vector spaces), matrices, theory of numbers, theory of equations.
   E. *Geometry:* Metric and other geometries (projective, affine, inversive), non-Euclidean geometries, differential geometry, topology.

F. *Foundations of Mathematics:* Theory of sets, mathematical or symbolic logic, postulates for geometry, postulates for algebra, postulates for arithmetic, the real and complex number systems.

3. *Supporting Science Courses:* Each undergraduate requirement should include a course in physics. The other hours should be chosen from the following: chemistry, biology, astronomy, geology, and meteorology.

PART 6. SUGGESTED COURSES IN SCIENCE AND MATHEMATICS FOR THE PREPARATION OF TEACHERS OF GENERAL SCIENCE

The suggested requirements listed herewith are predicated on these assumptions:

1. A teacher who has completed the specified major in any of the fields previously listed in this report (biology, chemistry, physics, physical science) will, with a minimum of additional background, be qualified to teach general science.
2. There is need for teachers to specialize in the teaching of general science at the junior high school level.
3. The science courses for the general science specialist should be such as to permit him to begin graduate work in some one of the sciences if he later decides to do so.
4. The teachers of general science should have a broad background in science and mathematics plus specialization in one or more areas of science.

Suggested Courses:	(Semester Hours)	
Biology	10	Plus 18 semester hours of upper division work selected from two or more of the four science fields (excluding mathematics) listed.
Chemistry	8	
Physics	12	
Earth Science*	6	
Mathematics	6	
Sub total	42	
Grand total	60	

* Material selected from the fields of geology, meteorology, and astronomy.

V. Miscellaneous

1. *The science methods course.* It is assumed that a science methods course will be available in each of these curricula. The two essential conditions for this to be a valuable course are centered in the qualifications of the instructor. He must be a person who is a scholar, well and solidly informed in the field of science; and he must be cognizant of and intelligently sympathetic toward the problems of secondary education. Given these qualities as a sine qua non, the question of the department of school in which the course should be taught becomes irrelevant and is a matter to be decided in terms of local institutional circumstances.
2. It is hoped that the students will receive training in the preparation and planning of materials for laboratory work and demonstration purposes.
3. *The fifth year.* A fifth year of work is strongly recommended. At least half of the course work during this year should be in science courses.
4. *Earth science.* The elements suggested for inclusion of the earth science course are enumerated in Section IV. No statement is made about preparation of teachers to teach earth science alone. Recommendation for preparation of teachers in such basic sciences as chemistry, physics, biology, mathematics, and physical or general science has been considered of major concern at this time.
5. *Credit to Maintain Certification.* Teachers who are required to take a certain number of credit hours work to maintain their certificates after several

years of teaching should take this work in their teaching field unless they already have sufficient background of basic and recent course work in that field.

6. *A synoptic view.* A survey of the requirements for the five science majors in this report (biology, chemistry, physics, physical science, and general science) shows that there exists a pattern of background common to all. Thus, each science major can be thought of as consisting of this common foundation plus certain additional preparation.

Specifically, the pattern of background common to all of the science preparations (but not including preparation for mathematics teaching) is:

Biology	6
Chemistry	8
Physics	8
Earth Science	3
Mathematics	6
Total	31

Because there is so much in common among these five curricula, it is quite practical for the prospective teacher to qualify in at least two of the five science areas involved in this report. Specifically, it is quite practical for the prospettive teacher of biology, chemistry, physics, or physical science to add a few more courses and qualify also as a teacher of general science. This combination, known in some places as a "comprehensive science major," is an ideal preparation for the modern teacher of science to high school students.

For the four year programs, the requirements are summarized in the table below. This synthesis of recommendations also suggests multiple qualification in secondary school science; for example, a teacher prepared in biology could also qualify in general science by taking four additional units in physics and three additional units in earth science.

	Common Foundation	Major in				
		Biology	Chemistry	Physics	Physical Science	General Science
Biology	6	24	2			4
Chemistry	8	4	20	5	10	
Physics	8			17	10	4
Earth Science	3				2	3
Mathematics	6		6	7	7	
Subtotal		28	28	29	29	11
Common total		31	31	31	31	31+18*
Grand total		59	59	60	60	60

* 18 units upper division work selected from two or more of the four science fields (excluding mathematics) listed above.

The Role of State Committees in Developing a Conservation Education Program*

Richard L. Weaver

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The author has attempted to ascertain the role of the state committees in the various states by means of a faculty research project from 1956 to 1958 which took me into all of the states except Rhode Island for a series of one-day conferences with state officials. The report of this research is now completed and available from the Dept. of Conservation at the University of Michigan. A summary of the portion of the research dealing with state committees forms the basis for the presentation in this paper.

Reasons for State Committees

1. The majority of state committees come into existence when the Department of Education needs a bulletin prepared. The State Superintendent usually appoints this committee with someone from his staff to work with it in developing the materials. The life of such committees is usually from one to two or three years. Thirteen states have had or still have such temporary committees. They are: Delaware, Georgia, Minnesota, Missouri, Nevada, New Hampshire, New Mexico, New York, North Dakota, Oregon, South Dakota, Vermont, and West Virginia.

2. Some twelve states have more or less permanent committee arrangements to develop and guide a state program in conservation education. Sometimes these are general curriculum committees which include conservation, such as in Tennessee, but more frequently they are set up with the primary emphasis on conservation, although they may be tied in with the general curriculum committee structure as in Michigan. In fact in Michigan the need for a conservation committee many years ago gave impetus to the formation of other permanent committees in the Department of Public Instruction.

These permanent committees are able to be of much greater service to a state when they can go beyond preparation of bulletins, valuable as that is. They can help design projects and programs, organize state and regional conferences, work with the colleges to stimulate in-service training, prepare needed materials, and coordinate efforts of consultants who work with schools and colleges. Likewise, they can evaluate various programs and activities and help schools and colleges

* A paper presented at the East Central Conservation Education Conference, Cumberland Falls State Park, Kentucky, November 7–9, 1958.

evaluate their programs.

Wisconsin has used such a permanent curriculum committee continuously since 1937 when their state program was launched after legislation was passed requiring the teaching of conservation in all schools. Likewise, Ohio and Illinois use permanent committees to guide their program. The Ohio committee is largely a committee of state agency representatives. Illinois once had teachers on the state committee, but a reorganization followed the employment of a state director and now the committee is a very small one composed of the heads of the cooperating agencies. It probably would not be proper to call either the Ohio or Illinois committees curriculum committees.

The following states have permanent state committees, councils or commissions: California, Idaho, Illinois, Kansas, Maryland, Michigan, New York, Ohio, Tennessee, Texas, Utah and Wisconsin.

In most cases these are appointed by the State Superintendent of Public Instruction.

The California State Committee is composed primarily of staff members of the Department of Education with one representative each from three other state agencies. There are no teachers on it. The committee serves primarily as a coordinating committee and a planning committee and gives clearance and direction to the several resource agencies interested in helping. Materials sponsored by the committee are frequently published cooperatively with the other agencies.

In some states where the Department of Education has not shown any great interest in conservation, voluntary state committees have come into existence with representation from the resource agencies and the colleges, universities and professional conservation organizations.

This was the case in Minnesota where the Natural Resources Council was formed in 1956. This idea grew out of representation of some of these groups at meetings of the Mid-West Conservation Education Conference. Here a concerted attempt is being made to get as many groups involved as possible. Their efforts will complement or supplement those of the temporary committees established to prepare a specific publication.

Ten states with voluntary committees are: Arkansas, Connecticut, Indiana, Illinois, Iowa, New Hampshire, Minnesota, Vermont, Virginia and Wyoming.

The Indiana committee was established primarily to bring about the enactment of a requirement for certain teachers to take a conservation course as a part of certification.

The New Hampshire Natural Resources Council is composed of representatives of lay or private groups and although agency per-

sonnel attend, they cannot hold office or vote. The Department of Education cooperates with the Council and encourages their interest and activities.

The Iowa and the Vermont committees studied their needs and recommended the establishment of permanent committees to replace theirs but so far unsuccessfully.

Such voluntary committees as these usually have to rely upon their organizations or agencies to assign or elect the representatives.

3. Another kind of function which cannot be performed too readily by the committees described so far, is that of serving as a coordinating group for all of the agencies and organizations interested in helping on conservation education matters.

Although the Michigan, California, Wisconsin, Ohio and Illinois committees make some effort of coordinating the state program, there is considerable difficulty because many of the groups are not represented on the committee. Likewise, these committees originate in the Departments of Education and to be in a better position to coordinate, their authority and responsibility really needs to come from the Governor or Legislature.

This was done in Wisconsin where a special coordinating job was needed to produce a resources guide for the state in which all agencies would assist. Thus the Legislature authorized a special committee for the purpose, composed of heads of state agencies, with the Governor as Honorary Chairman. The Vice-President of the University was chairman of the Education Sub-Committee. The Guide to Resources of Wisconsin was prepared and the committee will no doubt be dissolved.

In North Carolina a Resource-Use Education Commission was formed in 1946 with commission members receiving their appointments from the Governor. The Commission elected its own chairman and Executive Committee. The heads of state agencies were placed on the Commission because of their position. Institutional candidates were appointed by the presidents. Professional organizations elected or appointed their candidates. These were recommended to the Governor for appointment.

The Commission had 52 members and as Director of Resource-Use Education for the Department of Public Instruction, I served as the Commission Program Director and Secretary from 1947 to 1952.

We used sub-committees to activate projects in school camping, adult education, audio-visual and printed materials.

While having no administrative control of agencies to enforce coordination, much voluntary cooperation and coordination resulted because the heads of the agencies were members of the Commission

and could help decide the nature and extent of coordination needed and wanted.

The annual meetings of the Commission and the summer conferences sponsored, as well as the institutional committees organized to develop plans for their regions all served to bring the agencies, organizations and institutions together in a very worthwhile and healthy sort of way.

Unfortunately when I left and the State Superintendent who helped to organize it died, the Commission in North Carolina was abandoned.

The following states currently have Governor-appointed committees: Colorado, Florida, Maine and Oregon.

The committee in Colorado was established to design a state program and authorize the employment of a State Supervisor or Director. This was done and the Committee may be inactive now.

Florida's committee has functioned effectively since the mid-forties and has been able to continue despite the absence of a person at the state level to give a significant amount of time to the administrative details. A member of a university staff has had to assume these responsibilities.

4. Some states have not been able to have a state committee, council or commission established yet. It would be helpful if some foundation would make it possible for the states who have had successful experiences with committees to share their successes and experiences with those who would like to organize a state program with the help of a state committee, commission or council.

In summary, the special things which such committees can do effectively are:

a. Prepare and plan for distribution of printed and audio-visual materials on:
   i) the resources of the state
   ii) effective methods of teaching conservation
   iii) leadership techniques
   iv) bibliographies and lists of materials and resources personnel.
b. Activate resource agencies to assist in conservation education and help to channel their efforts into the most effective types of service.
c. Assist institutions in their efforts to provide pre-service and in-service training in conservation.
d. Sponsor state and regional conferences, summer institutes and workshops, and local meetings of teachers to increase interest and emphasis on conservation.
e. Help the Department of Education to evaluate the present status of conservation in the state, the current progress and the future needs.

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The Elementary School Science Library for 1958*

Paul E. Kambly

School of Education, University of Oregon, Eugene, Oregon

This is the fifteenth yearly list of books for elementary school science compiled and published in SCHOOL SCIENCE AND MATHEMATICS. The purpose, like that of preceding lists, is to suggest to elementary school teachers books that are supplementary to basic text series either for their values as sources of information or for recreational reading. Certain books included primarily because of assumed value as recreational reading are below desired standards of good sources of science information. The sub-division topics are of no significance except as an aid in grouping the books.

Exact grade placement is difficult because of variations in pupil reading ability as well as in different uses made of the books. The lowest grade levels for pupil use are indicated.

BOOKS FOR ELEMENTARY SCHOOL SCIENCE[1]

Ancient Animals

	Grade	*Price*
Ancient Elephants. By William E. Schule. 64 pp. '58. World..... An introduction to the mastodons and mammoths. Describes and illustrates the ancient elephants and notes the three kinds of elephants in existence today.	4	$2.50
Prehistoric Animals. By Jane Werner Watson. 56 pp. '58. Simon.. Adapted from *Life.* Explains how and why some ancient animals disappeared. Colored photographs.	4	.50
What Dinosaur Is It? By Anna Pistorius. 29 pp. '58. Follett..... Colored illustrations and informative text describe approximately 35 different kinds of prehistoric animals.	4	2.25

Animals

(See also list of books on birds and insects)

A Book of Tails. By Anne Welsh Guy. 48 pp. '57. Steck..... Primarily a picture book for small children which emphasizes the different uses that various animals make of their tails. Some teachers may object to "talking" animals that also seem to be able to reason.	1	1.50
Here Come the Wild Dogs. By Alice E. Goudey. 91 pp. '58. Scribner The habits and behavior of the red fox are described in a story of a particular fox family. Attractively illustrated.	2	2.50
Our Largest Animals. By Morton S. Malter. 32 pp. '58. Whitman. The blue whale, bush elephant, African ostrich, giant tortoise, giant squid, regal python, anaconda and the Komodo dragon are described and illustrated in color.	2	2.00

* This is an annual contribution from Dr. Kambly, and serves as the second article in our "Elementary Science and Mathematics" series.

[1] Publishers and their addresses are listed at the end of this section.

	Grade	*Price*
The Armadillo. By Theodore W. Munch and M. Vere DeVault. 32 pp. '58. Steck. An easy-to-read book about the structure and life habits of the nine-banded armadillo. Illustrated in color and black and white.	2	1.50
Where Animals Live. By Terry Shannon. 32 pp. '58 Whitman. A book best suited for recreational reading. Illustrations by Charles Payzant show animals living off the ground, in the water, on the ground and under the ground.	2	2.75
Buzztail. By Robert M. McClung. 64 pp. '58. Morrow. The story of one year in the life of a six foot timber rattlesnake which emphasizes the structure and life of the snake but includes some of the other animals he encounters. Good drawings help make this an informative book.	3	2.50
Kangaroos and Other Animals with Pockets. By Louis Darling. 64 pp. '58. Morrow. The characteristics and habits of kangaroos, marsupial mice, marsupial tiger cats, wombats, koalas and several other marsupials. Excellent drawings help to make this a good book for helping children learn about these animals with pouches.	3	2.50
Let's Go to a Zoo. By Laura Sootin. 48 pp. '59 Putnam. How the animals are housed, displayed, fed and otherwise cared for. Emphasizes the operation of a zoo rather than the many different types of animals displayed.	3	1.95
Snails. By Dorothy Hogner. 81 pp. '58. Crowell. Easy-to-read book which describes land, freshwater, and saltwater snails. Excellent drawings help to identify the various types.	3	2.50
White-tail; the Story of a Prairie Dog. By Rutherford George Montgomery. 64 pp. '58. World. The life cycle and living habits of a prairie dog in the Rocky Mountain region.	3	2.50
Wild Animals. By Walter Suschitzky. 72 pp. '58. Simon. Over seventy excellent pictures, accompanied by informative text, explain how wild animals live.	3	.50
All About Animals and Their Young. By Robert M. McClung. 148 pp. '58. Random. How different kinds of animals reproduce and care for their young. Includes examples of "simple" animals as well as insects, reptiles, birds and mammals.	4	1.95
All About Monkeys. By Robert S. Lemmon. 144 pp. '58. Random. How monkeys have developed through the ages; the different kinds that are found today; where they live and how they behave.	4	1.95
The Golden Book of Animals. By Anne Terry White. 96 pp. '58 Simon. Seventy-five wild animals are shown in life-like photographs and described in brief accompanying text. Pictures by Walter Suschitzky.	4	2.95
Walt Disney's Widllife of the West. By Willis Lindquist. 56 pp. '58. Simon. About animals that live on our western mountains, prairies and deserts.	4	.50
Wild Animals of the Far West. By Adrien Stoutenberg. 150 pp. '58. Parnassus. Characteristics, habits, and ranges of over 100 of the most common or most interesting species of wild animals found in the U. S. west of the Continental Divide.	4	3.75

	Grade	Price
A Beaver's Story. By Emil E. Liers. 192 pp. '58. Viking. The family life, dam building activities, and adventures of a pair of beavers and their kits in the woodland marshes and bottom lands.	5	3.00
Animal Tails. By George F. Mason. 95 pp. '58. Morrow. Describes the great variety of animal tails and the ways in which animals use them. Many line drawings supplement the text.	5	2.50
Winter-Sleeping Wildlife. By Will Barker. 136 pp. '58. Harper. The life and habits of several North American mammals, reptiles and insects that hibernate. Sparsely but accurately illustrated.	6	3.00
Astronomy		
The Littlest Satellite. By Inez Hogan. 32 pp. '58. Dutton. A story that includes gnomes and fairies but does introduce small children to some of the concepts and vocabulary of space science.	1	2.50
Let's Go to a Planetarium. By Louis Wolfe. 48 pp. '58 Putnam. Describes a planetarium and the type of show provided for visitors.	4	1.95
Neighbors in Space. By W. B. White. 62 pp. '58. Rand. Descriptions and diagrams of some of the constellations. Approximately half of this book is devoted to the sun and the solar system.	4	1.00
Shooting Stars. By Herbert S. Zim. 64 pp. '58. Morrow. An introduction to what is known about meteors and meteorites. Large drawings supplement the text and help to make this another good book by a well known author.	4	2.50
The Adventure Book of Stars. By Tom Nicholson. 120 pp. '58. Simon. A star-guide which will help young people to get acquainted with outer space. Seasonal star-charts have guide lines to aid in locating constellations.	4	2.95
Exploring the Planets. By Roy A. Gallant. 123 pp. '58. Garden City. Theories on the formation of the solar system and a description of each of the nine planets.	5	2.95
Exploring the Sun. By Roy A. Gallant. 56 pp. '58. Garden City. Man's early beliefs about the sun, its physical phenomena and its influence on the earth. Concludes with a theory of how the sun will eventually "burn" itself out.	5	2.50
The Golden Book of Astronomy. By Rose Wyler and Gerald Ames. 100 pp. '58. Simon. Explanations of day and night, the moon's phases, and the earth's seasons. Also explains how man may build a rocket to deliver him to some place in outer space.	5	3.95
Birds		
Birds. By Jane Werner Watson. 56 pp. '58. Simon. Shows about fifty of our most familiar birds. An excellent "first book" on bird identification.	2	.50
The Road Runner. By Theodore W. Munch and M. Vere DeVault. 30 pp. '58. Steck. The physical characteristics, habits, behavior and habitat of the road runner, a fascinating bird of the Southwest. Attractive accurate illustrations, some in full color on every page.	2	1.50

	Grade	*Price*
White Patch—A City Sparrow by Olive L. Earle. 64 pp. '58. Morrow. The story of a sparrow who survives his first winter and then helps raise three broods during the following summer. Excellent black and white drawings appear on almost every page.	2	2.50
Robins on the Window Sill. By Irmengarde Eberle. 42 pp. '58. Crowell. A sequence of photographs show the family-raising activities of a pair of robins from the time they built their first nest on his window sill until the fledglings left the nest. The close-up photographs are excellent.	3	2.75
Ostriches. By Herbert Zim. 64 pp. '58. Morrow. The structure, relationships and life habits of ostriches and their relatives. Many drawings help to supplement the text.	4	2.50
Penguins on Parade. By Patricia Lauber. 62 pp. '58. Coward-McCann. A well-illustrated book which describes clearly the physical characteristics, habits and behavior, and natural habitats of different species of penguins.	4	3.00
Birds of the World. By Eunice Holsaert. 56 pp. '58. Simon. Stresses feeding, nesting habits, patterns of migration, and special adaptations for flight.	5	.50
Conservation		
Dust Bowl: the Story of Man on the Great Plains. By Patricia Lauber. 96 pp. '58. Coward-McCann. An account of the Great Plains before the coming of the first settlers; traces the factors which caused the dust bowl and recounts what has been done to prevent further erosion to the land.	5	2.50
Water: Our Most Valuable Natural Resource. By Ivah Green. 96 pp. '58. Coward-McCann. Water as a natural resource and soil erosion and its prevention. Clear text and numerous photographs.	5	3.50
General Nature Study		
The True Book of Deserts. By Elsa Posell. 48 pp. '58. Children's Press. General characteristics of deserts and some of the plants and animals which inhabit them. Many large illustrations and easy-to-read text.	1	2.00
Desert Dwellers. By Terry Shannon. 32 pp. '58. Whitman. Plants and animals on American deserts are described. Excellent illustrations in color and in black and white by Charles Payzant supplement the text.	2	2.75
Nature Detective. By Millicent Selsam. 44 pp. '58. W. R. Scott. Where to look for clues to what has happened in nature. Tracks, feathers, holes, shells and similar items are clues that may encourage some children to study nature as a hobby.	2	2.75
At Waters Edge. By Terry Shannon. 48 pp. '58. Sterling. Colorful presentation of some plants and animals found around the edges of bodies of water.	3	2.50
Plants and Animals. By Jane Werner Watson. 56 pp. '58. Simon The main groups of plants and animals, how they differ, and how they live and grow.	3	.50
See Through the Lake. By Millicent Selsam. 44 pp. '58. Harper. Exploration of the community of plants and animals that live at different levels in a lake.	3	3.25

	Grade	*Price*
See Up the Mountain. By Betty Morrow. 47 pp. '58. Harper. The climate, soil, plant and animal life which are typical of each zone from the foothills to the snowy peak of a mountain. Colored illustrations supplement the text.	3	3.25
Snow Tracks. By Jean George. 62 pp. '58. Dutton. Text and drawings tell what happens after a snow storm as indicated by the tracks on the clean white page of snow.	3	2.50
The Deep Sea. By Marie Neurath. 36 pp. '58. Sterling. Simple text describes some of the interesting creatures that live in the depths of the sea.	3	2.00
Too Small to See. By Marie Neurath. 36 pp. '58. Sterling. A magnifying glass is used to examine such things as a fly's leg, a drop of water, and a cat's tongue.	3	2.00
Pets from the Pond. By Margaret Waring Buck. 72 pp. '58. Abingdon. How to find, catch, transport, keep and feed; clams, fishes, tadpoles, frogs, salamanders, turtles, crayfish and insects. Illustrated with clearly detailed line drawings.	4	3.00
The Golden Book of Nature Crafts. By John Richard Saunders. 67 pp. '58. Simon. Clearly written directions for collecting feathers, spider webs, butterflies and wood; casting for animal tracks and building and filling an insect zoo. Illustrated with colored photographs.	4	1.95
Walt Disney's White Wilderness. By Robert Louvain. 56 pp. '58. Simon. Excellent information about adaptations and interrelationships of living things of the Arctic.	4	.50
Wild Folk in the Desert. By Carroll Lane Fenton and Evelyn Carswell. 128 pp. '58. Day. Includes both animal and plant life of the deserts of western North America. Excellent drawings supplement the informative text.	4	3.50
Wild Folk in the Mountains. By Carroll Lane Fenton. 96 pp. '58. Day. Includes plant and animal life found mostly in the mountains in western United States. Many excellent drawings supplement the interesting text.	4	3.00
Boy Beneath the Sea. By Arthur C. Clarke. 64 pp. '58. Harper. Forty-nine photographs of various types of coral and fish by Mike Wilson make this a book that most boys will enjoy.	5	2.50
The Sea and Its Mysteries. By William M. Hutchinson. 32 pp. '58. Maxton. Tides, waves, ocean currents and some of the forms of plant and animal life that live in the sea. Many illustrations with some in color.	5	1.50
General Science		
Busy Water. By Irma S. Black. 33 pp. '58. Holiday. Beginning with rain falling on a high hill, text and pictures trace the water cycle to tell where the rain comes from and some of the uses of water.	1	2.50
Dan the Weatherman. By Jene Barr. 32 pp. '58. Whitman. Pictures by P. J. Hoff, who is a weatherman. A very easy to read introduction to various aspects of weather and weather instruments as well as how various people feel about weather.	1	1.25
The True Book of Oceans. By Katherine Carter. 47 pp. '58. Children's Press.	1	2.00

	Grade	*Price*
What an ocean is, its floor, surface, shore, tides, currents, plant and animal life and its usefulness to man are described in simple text.		
Who Built the Dam? By Norman Bate. 28 pp. '58. Scribner..... A picture story about the building of a hydroelectric dam and of the machines used to build it.	1	2.50
The True Book of Rocks and Minerals. By Illa Podendorf. 48 pp. '58. Children's Press..... An introduction to rocks and minerals and how they are formed. Many large illustrations in both color and black and white.	2	2.00
Between Earth and Sky. By Marie Neurath. 36 pp. '58. Sterling.. How a tornado starts, what the "eye" of a hurricane looks like, why we see lightning before we hear thunder, and many other interesting facts.	3	2.00
Deep Treasure. By Elizabeth Olds. 42 pp. '58. Houghton..... The story of how men came to believe that oil could be found in various places. Illustrated in color and black and white.	3	3.00
Energy and Power. By Robert Irving. 140 pp. '58. Knopf..... Defines energy and power, explores the various forms and sources of energy, and tells how man has harnessed and put it to use.	3	2.75
Magnets and How to Use Them. By Tillie S. Pine and Joseph Levine. 48 pp. '58. Whittlesey..... Many diagrams help to explain the characteristics and uses made of various types of magnets.	3	2.50
The Arctic Tundra. By Delia Goetz. 64 pp. '58. Morrow..... Weather conditions, plant and animal life and the tribal groups who live in the arctic tundra are described in simple text with excellent illustrations.	3	2.50
Among the Rocks. By Terry Shannon. 48 pp. '58. Sterling..... Basic information needed for starting the study and classification of rocks and minerals.	4	2.50
Andy's Wonderful Telescope. By Warren G. Schloat. 48 pp. '58. Scribner..... The relationship of the earth to the universe, how the telescope was developed and what can be seen through it. Andy is the boy in the photographs which add interest and value to the book.	4	2.75
Let's Go to the Telephone Company. By Naomi Buchheimer. 48 pp. '58. Putnam..... A behind the scenes account of what happens when you use a telephone. Many diagrams help to clarify the simplified but still technical explanations.	4	1.95
Let's Go to a Television Station. By Naomi Buchheimer. 48 pp. '59. Putnam..... Emphasizes how a television program is put on rather than the way television works.	4	1.95
Machines. By Jerome Sydney Meyer. 63 pp. '58. World..... The wheel and axle, the lever, the screw, and the wedge explained in easy-to-understand terms and clear black and white drawings.	4	2.50
Singing Strings. By Larry Kettelkamp. 48 pp. '58. Morrow..... Harps, the piano family, the guitar family, and the violin family are discussed. There are clear instructions for making simplified versions of each of these types of instruments. An excellent book to supplement any unit involving the study of sound.	4	2.75
What Makes It Go? By Rose Wyler and Gerald Ames. 64 pp. '58. Whittlesey.....	4	2.50

	Grade	*Price*
Text and drawings help children understand the operation of cars, planes, locomotives and other types of machines.		
Aluminum, the Miracle Metal. By C. B. Colby. 48 pp. '58. Coward-McCann. How aluminum is made and how it helps to make much of our modern way of living possible.	5	2.00
Engines, Atoms and Power. By Amabel Williams-Ellis. 64 pp. '58. Putnam. Eight chapters, beginning with some of the work of men such as Benjamin Franklin, John Dalton, James Watt and ending with a chapter on nuclear power.	5	2.00
Science in Your Own Backyard. By Elizabeth K. Cooper. 192 pp. '58. Harcourt. Simple experiments involving soil and rocks, fossils, water, grasses, flowers, plants, birds, insects, animals, clouds, weather and stars.	5	3.00
The First Book of the Earth. By Opal Miner. 62 pp. '58. Watts. The origin of the earth and its composition; the formation of rocks, mountains, rivers and glaciers; causes of earthquakes and volcanoes and other geological phenomena.	5	1.95
The Sea. By Emma Gelders Sterne and Barbara Lindsay. 56 pp. '58. Simon. Illustrations from *Life* are supplemented by the text. How the sea began; the development of life; coral reef gardens; tides, waves and currents and their effect on living things.	5	.50
Underground Riches. By Walter Buehr. 95 pp. '58. Morrow. An introduction to the study of the materials stored in the earth and the ways they have been and are now being mined. The mining of gold, coal, and iron is described in the last three of eight chapters.	5	2.50
You and the Earth Beneath Us. By Julian May. 64 pp. '58. Children's Press. Information about rocks, minerals, volcanoes, mountains, earthquakes, caves, glaciers, soil, fossils and other features of the earth.	5	2.00
Experiments with Light. By Nelson Beeler and Franklyn Bromley. 143 pp. '58. Crowell. Nature and behavior of light are explored in experiments which also explain the construction, principles and operation of lenses, microscopes and other instruments. Well illustrated.	6	2.75
Exploring Chemistry. By Roy A. Gallant. 120 pp. '58. Garden City Traces the development of chemistry through the discoveries of scientists. Recent advances and a few of the current problems facing chemists are included.	6	2.95
Orbit—a Picture Story of Force and Motion. By Hy Ruchlis. 147 pp. '58. Harper. Describes Newton's Laws of Motion—inertia, acceleration and momentum, and action and reaction—and his Law of Gravity. Many photographs and drawings help clarify the concepts presented.	6	2.75
Young Peoples Book of Science. By Glenn O. Blough. 448 pp. '58. Whittlesey. Although intended primarily for teen age boys and girls this book on living things, weather, atoms, space, electrons and the sea will be of interest to younger good readers interested in science.	6	4.50

	Grade	*Price*
Insects		
I Like Caterpillars. By Gladys Conklin. 32 pp. '58. Holiday. Primarily a picture book. It does not include pictures of the adult stage of the caterpillars shown.	1	2.75
What Is a Butterfly? By Lucy and John Hawkinson. 48 pp. '58. Benefic Press. Kinds of butterflies, physical characteristics, metamorphosis and benefit to man. Controlled vocabulary and attractive pictures. Similar books by the same authors are *What Is a Fish? What Is a Frog?* and *What Is a Tree?*	3	1.60
Butterflies and Moths. By R. A. Martin. 56 pp. '58. Simon. Life cycles of butterflies and moths. Colored illustrations help in identifying some common species.	4	.50
Physiology		
Sweetest Story Ever Told. By Frank Jupo. 48 pp. '58. Sterling. The story of sweets from primitive times to the present. Simply written, interesting text that might be useful in a study of foods.	3	2.25
All About the Human Body. By Bernard Glemser. 136 pp. '58. Random. A description of human anatomy, the function of different organs and how they work together in a living human organism.	4	1.95
Lifeline—The Story of Your Circulatory System. By Leo Schneider. 127 pp. '58. Harcourt. A clear concise description of the circulatory system and the way it functions.	5	2.95
Plants		
How Does a Garden Grow? By Ann Torson Brown. 48 pp. '58. Dutton. Two children choose seeds, layout a garden plan, prepare and plant flats, thin and transplant, prepare outdoor soil and care for a garden through the season.	3	2.50
Plant Hunters. By Frances L. Jewett and Clare L. McCausland. 230 pp. '58. Houghton. Describes some experiences of men who spent their lives hunting plants from all over the world which could be raised in the United States.	6	3.00
Strange Plants and Their Ways. By Ross E. Hutchins. 96 pp. '58. Rand. Begins with a general discussion of plant growth. Includes chapters on mistletoe, dodder, lichens, mangrove trees and slime molds. Sixty excellent photographs taken by the author.	6	2.95
Rockets, Jets and Space Travel		
Moon Trip—True Adventure in Space. By William Nephew and Michael Chester. 64 pp. '58. Putnam. Tells why men want to go to the moon, how they are likely to reach it and what it will be like when they arrive.	4	2.50
You and Space Travel. By John Lewellen. 60 pp. '58. Children's Press. Principles of flight and their application to space travel. This is a new edition of a book first published in 1951.	4	1.50
Rockets Around the World. By Erik Bergaust. 48 pp. '58. Putnam. A report on what the United States, Soviet Union, France, Great Britain, Canada, Australia, Switzerland, Sweden, Japan,	5	2.00

	Grade	*Price*
and Italy are doing in the race to develop rockets. Boys will be especially interested in the many photographs.		
Wider Than the Sky. By Charles M. Daugherty. 158 pp. '58. Harcourt	6	2.95
Traces the development of aviation to present day accomplishments with jets, missiles and rockets. Also stresses current vocational opportunities in aviation.		

Transportation

Three Boys and a Helicopter. By Nan Hayden Agle and Ellen Janet Wilson. 122 pp. '58. Scribner	3	2.50
Boys build a play whirlibird and then, during a flood, get to ride in a real helicopter. Easy-to-read information about this type of aircraft.		

Miscellaneous

The First People in the World. By Gerald Ames and Rose Wyler. 48 pp. '58. Harper	3	2.95
The story of man's development on the earth. Illustrated in both color and black and white.		
First Days of the World. By Gerald Ames and Rose Wyler. 48 pp. '58. Harper	4	2.95
The story of the earth's beginning to the time that living things appeared.		
Our World. By E. Joseph Dreany. 32 pp. '58. Children's Press	5	1.50
How the earth was formed, early life on the earth, how the earth's surface changes and resources used by man. Illustrated in color and black and white.		
They Wanted the Real Answers. By Amabel Williams-Ellis. 64 pp. '58. Putnam	5	2.00
Stories about some of the discoveries of Aristotle, Pasteur, Darwin and Edison.		
Research Ideas for Young Scientists. By George Barr. 142 pp. '58. Whittlesey	6	3.00
A book that starts with the assumption that the reader has already learned many things and makes suggestions for using this knowledge to help learn more. A very useful book to help keep interested and intelligent pupils productively working.		
Young Thomas Edison. By Sterling North. 182 pp. '58. Houghton	6	1.95
An interesting biography telling of a lifetime of experimentation and scientific achievement.		

Publishers and Their Addresses

Abingdon: Abingdon-Cokesbury Press, 810 Broadway, Nashville 2, Tennessee.
Benefic Press: Beckley Cardy Company, 1900 N. Narragansett, Chicago 39, Illinois.
Children's Press: Children's Press, Jackson Blvd. and Racine Avenue, Chicago 7, Illinois.
Coward-McCann: The John Day Company, 121 Sixth Avenue, New York 13, New York.
Crowell: Thomas Y. Crowell Company, 432 Fourth Avenue, New York 16, New York.
Day: The John Day Company, 121 Sixth Avenue, New York 13, New York.
Dutton: E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, New York.

Follett: Wilcox and Follett, 1255 Wabash Avenue, Chicago 5, Illinois.
Garden City: Garden City Books, 575 Madison Avenue, New York 22, New York.
Grosset: Grosset and Dunlap, Inc., 1107 Broadway, New York 10, New York.
Harcourt: Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York 17, New York.
Harper: Harper and Brothers, 750 Third Avenue, New York 17, New York.
Holiday: Holiday House, 8 West Thirteenth, New York 11, New York.
Houghton: Houghton Mifflin Company, 2 Park Street, Boston 7, Massachusetts.
Knopf: Alfred A. Knopf, Inc., 501 Madison Avenue, New York 22, New York.
Maxton: Maxton Publishers, Inc., 15 East Twenty-sixth Street, New York 10, New York.
Morrow: William Morrow and Company, 425 Fourth Avenue, New York 16, New York.
Parnassus: Parnassus Publishing Company, 33 Paranassus Road, Berkeley 8, California.
Putnam: G. P. Putnam's Sons, 210 Madison Avenue, New York 16, New York.
Rand: Rand McNally and Company, 111 Eighth Avenue, New York 11, New York.
Random: Random House, Inc., 457 Madison Avenue, New York 22, New York.
Scribner: Charles Scribner's Sons, 597 Fifth Avenue, New York 17, New York.
Simon: Simon and Schuster, Inc., 630 Fifth Avenue, New York 20, New York.
Steck: Steck Company, Ninth and Lavaca Streets, Austin 1, Texas.
Sterling: Sterling Publishing Company, Inc., 419 Fourth Avenue, New York 16, New York.
Viking: The Viking Press, 625 Madison Avenue, New York 22, New York.
Watts: Franklin Watts, Inc., 699 Madison Avenue, New York 21, New York.
Whitman: Albert Whitman and Company, 560 West Lake Street, Chicago 6, Illinois.
Whittlesey: McGraw-Hill Company, 330 West Forty-Second Street, New York 36, New York.
World: World Book Company, 313 Park Hill Avenue, Yonkers 5, New York.
W. R. Scott: William R. Scott Inc., 8 West Thirteenth Street, New York 11, New York.

PROPOSED AMENDMENT

According to the By-Laws of the Central Association of Science and Mathematics Teachers, all proposed amendments to the By-Laws must be published in two successive issues of SCHOOL SCIENCE AND MATHEMATICS to give the membership an opportunity to express its views to the Board of Directors. The following revision was proposed at the recent annual convention.

Proposed By-Laws Revision:

Article I, Section IV. DUES:

New	Old
The annual dues of each member of the Association shall be set by the Board of Directors and will be payable in advance. The annual dues . . . the *Journal.*	The annual dues of each member of the Association shall be $3.50, payable in advance. The annual dues . . . the *Journal.*

One Hundred Years Without Darwinism Are Enough*

H. J. Muller

Zoology Department, Indiana University

1. The Establishment of the Theory

One hundred years ago, on July 1, 1858, Charles Darwin and Alfred Russell Wallace made their joint announcement of the theory of evolution by natural selection, at a meeting of the Linnean Society of London. In the following year, Darwin, in what was undoubtedly the greatest scientific book of all time, presented the evidence that he had gathered and developed during the previous 20 years for this revolutionary view of life. His treatment was so unprecedented, so comprehensive, and so masterly as first to stagger and then to convince all whose minds were mobile enough to follow his arguments adequately. Since that time, the whole matter has been subjected to the most copious and exacting criticism, and to ever more searching exploration and testing. The result has been that this principle of living nature now stands as one of the most firmly established generalizations of science and that far more is now understood about the manner by which evolution operates than was even imagined a century ago.

At this point some people will wish to object, saying that after all evolution is not a *fact*. These people are apt to be the very ones who in some other fields are the most willing to accept without question doctrines that cannot be scientifically proved. I would however ask these objectors in return: what is a fact and how is anything demonstrated to be true? The honest scientist, like the philosopher, will tell you that nothing whatever can be or has been proved with fully 100% certainty, not even that you or I exist, nor any one except himself, since he might be dreaming the whole thing. Thus there is no sharp line between speculation, hypothesis, theory, principle, and fact, but only a difference along a sliding scale, in the degree of probability of the idea. When we say a thing is a fact, then, we only mean that its probability is an extremely high one: so high that we are not bothered by doubt about it and are ready to act accordingly. Now in this use of the term fact, the only proper one, evolution is a fact. For the evidence in favor of it is as voluminous, diverse, and convincing as in the case of any other well established fact of science concerning the existence of things that cannot be directly seen, such as atoms, neutrons, or solar gravitation.

The protracted reaches of earth's history, with their long-drawn-out processes of transformation, stare us plainly in the face. Wander

* Address to Central Association of Science and Mathematics Teachers, delivered at Indianapolis, Nov. 28, 1958. Contribution No. 667 of Zoology Dept., Indiana University.

along a brook in Indiana and examine the stones: the dead relics of exotic creaures of the sea that crawled here many millions of years ago when this land was under water are to be picked up right and left. Now follow with the geologist and trace these changes and others grade by grade. Then delve into the history of your own body, as it unfolded its heritage from the egg, and note the dim rehearsal of past events that it seems so unnecessarily to go through, as by some ritual incantation recounted every generation anew: in your early stages *your* gill slits, *your* fish's heart, fish's brain and fish's circulation, then later *your* split lip, your pointed ear, your coat of body hair, your tail. And note the traces of some of these obsolete structures, in lowly creatures so useful, even in your adult selves. Next, accompany the breeder of plants and animals to his farm, and let him show you his new and fancy varieties. Compare them with the records of their ancestors and then, if you can, deny the extraordinary plasticity of protoplasm.

Even as our knowledge of atoms allows us to make atomic reactors and bombs, so our knowledge of how evolution works is now detailed and practical enough to have enabled us to produce strains of the mold *Penicillium* that give us more than ten times the original yield of pencillin, to produce wheat in which we have implanted a resistance to leaf rust obtained from the grass *Aegilops*, and (so we may infer!) to produce disease bacteria of increased virulence against which, on the other hand, we are trying to prepare immunological defenses for use in case of biological warfare.

So enormous, ramifying, and consistent has the evidence for evolution become that if anyone could now disprove it, I should have my conception of the orderliness of the universe so shaken as to lead me to doubt even my own existence. If you like, then, I will grant you that in an absolute sense evolution is not a fact, or rather, that it is no more a fact than that you are hearing or reading these words.

2. The Disregard of the Theory

It ill befits our great people, four generations after Darwin and Wallace published their epochal discovery of evolution by natural selection, to turn our backs on it, to pretend that it is unimportant or uncertain, to adopt euphemistic expressions to hide and soften its impact, to teach it only as one alternative theory, to leave it for advanced courses where the multitudes cannot encounter it, or, if it is dealt with at all in a school or high school biology course, to present it as unobtusively and near the end of the course as possible, so that the student will fail to appreciate how every other feature and principle found in living things is in reality an outgrowth of its universal operation.

Are we teachers in whose hands lies the responsibility of bringing to the next generation a true and modern view of the nature of things, as gained by the devoted efforts of the world community of critical scientific minds, not deeply ashamed that we have been so remiss in our task of awakening in that developing generation an adequate realization of the most basic forces of life and of how these forces have worked and are still working to give rise to all life's outer manifestations? Why dabble around with the superficialities of our subject and bemuse our young charges with technical terms and baffling complexities if we do not make fully clear to them the deepest known meanings and unifying underlying principles and if we do not show from step to step, in true perspective, the ways in which these principles have engendered all the other manifold features of living things? Surely the groping minds of boys and girls cannot be expected to piece together for themselves, with only a few clues here and there, that great evolutionary picture which before Darwin had eluded nearly all the creative thinkers of mankind. And yet, if presented in forthright fashion, that picture can be readily apprehended.

We need, in these decisive days of world tension, when free men will stand or fall according to how fully they recognize and act upon the most honest views of the truth that they can glean, to execute a complete about-face in this critical area of education. We dare not leave it to the Soviets alone to offer men the inspiration that is to be gained from the wonderful world view opened up by Darwin and other Western biologists. This view, founded so solidly upon the discoveries of modern science, is, when fully incorporated into men's personalities, the source of the profoundest idealism and hope. It should lend us support in our struggle for a freer world. For it shows how the most essential properties of living things have led to their perpetual reaching out, self-transformation, progression, and conquest of the rest of nature, until from a slimy scum they have stood erect, become aware of themselves, evolved social feelings and moral principles, and striven toward the stars. It shows that this great process is still at work and that we can carry it further. But, analyzing the manner of operation of these forces, and noting the millions of species that have fallen by the way, this view of things also points to the practical dangers, and leads us to seek ways of avoiding the pitfalls and the insidious deflections of course that would otherwise cause disaster again.

Boys and girls in grade and high school are by no means too young for such lessons. But we must devote ourselves with a will to the most effective means of instilling them, and of making them a basic part of the child's outlook on all things around him. He must not be al-

lowed to lose the forest for the trees but must always think of the trees as a part of the great and growing forest. I well remember the deep impression made on me when at the age of seven or eight I saw the series of fossil horses' legs at the Natural History Museum and listened to my father explain how they had come about as a result of the ever speedier variants escaping better from the carnivores generation after generation. The essential basis of natural selection, given in this form, is easily grasped by any child and, once grasped, it should be applied to case after case as these cases are encountered.

The memory is also vivid with me of how thrilled I was when, as a boy of about 15 in Sunday school more than half a century ago, I was read a famous poem (it is probably familiar to most of the readers of this article) that went *something* like this:

> "A fire mist and a planet,
> A crystal and a cell,
> A jellyfish and a saurian,
> And a cave where the cave men dwell;
> Then a sense of law and beauty
> And a face turned from the clod:
> Some call it evolution
> And others call it"—*racial development!*

The text called "Modern Biology" which has been assigned in many high school classes in Indiana and elsewhere fails to contain the word evolution in the index or anywhere else. It does, however, in its next-to-the-last chapter have a moderately acceptable discussion of evolution, without using the word. This treatment, unfortunately, comes at too late a point to allow consideration of all other parts of biology as manifestations of evolution. Moreover, the words "*racial development*" are given, in heavy print (p. 655), as the term by which this principle of nature is known! What better expression could be devised for veiling from one's view the awe-inspiring pattern by which primeval life progressively and divergently flowered out into all kinds of living beings, including ourselves!

Is it not clear that, if this imposing view of the course taken by living things is as true as all our criteria demonstrate it to be, we have no right to mince words about it, and basely to prevent our children from learning by what term this grandest principle in nature is properly known? And while it is all to the good to have a chapter, following this, on conservation, that is, on the means of preserving for ourselves the present fruits of this evolution, it is unworthy of our trust as educators if we stop here, as though the process were now finished. Surely we must go on from here to point out that there is no reason to suppose this to be the end of the story. Instead, it may be more nearly the beginning since, with our own knowledge of the processes involved, we may be able to carry the progression onward to heights

previously undreamed. Or do we actually rely on the child to come to these inferences on his own?

Certainly we in Indiana are no more to blame in these respects than many or most other American communities are. Teachers beyond the prime of life may well remember the furor created throughout the country a third of a century ago by the Scopes trial in Tennessee. In those same years the house of representatives in Texas (where I was then teaching), as well as in several other states, passed a bill prohibiting the teaching of evolution in the schools. At the same time the Texas text book commission decided that all school and high school texts in that state must be purged of this nefarious doctrine. It is true that the Scopes trial itself more or less fizzled out. However, the intimidation that was behind it has remained and even grown.

A study published in 1942 by the Commission on the Teaching of Biology of the Union of American Biological Societies* showed that even then less than half of the high school teachers of biology taught evolution as the principle underlying the development of all living things. There has been little evidence of improvement since that time. It was found in that study that some of those who failed to teach evolution did so because they themselves had not been well enough educated to recognize the truth of it. However, more of the teachers had been browbeaten by the dread that the teaching of this subject would arouse the opposition of administrators or of the public. With the passage of time, this ostrich policy has become, if anything, even more firmly fixed, despite the fact, or rather, *because* of the fact, that this field is so pregnant in its implications for everyone. Thus do we fail our youth.

3. The Theory Advances

Yet during all this time the subject itself has moved forward. Although it has become abundantly clear that the Darwinian principle of the natural selection of randomly occurring variations lies at the basis of all evolution, much more is now known of what in turn, in the make-up of living things, lies behind this principle and gives rise to it, and much more is also known about how it works out in practice to cause evolution to go this way or that way or to fade into stagnation or change to retrogression. Moreover, much of the essence of these facts is simple eough and important enough to be taught to youngsters. This being the case, it is their prerogative to have the opportunity to learn it. Evolution teaching must not stop with Dar-

* "The Teaching of Biology in Secondary Schools of the United States: a Report of Results from a Questionnaire," by O. Riddle (editor), F. L. Fitzpatrick, H. B. Glass, B. C. Gruenberg, D. F. Miller and E. W. Sinnott, sponsored and published by The Committee on the Teaching of Biology of the Union of American Biological Societies, 76 pp. (1942).

win, Mendel and deVries, plus a mere smattering of chromosome patter. Like knowledge of the meaning and implications of atomic energy or rocket operations, this subject must be brought up to date for the rising generation.

We have to catch up from our hundred years of being practically without Darwinism in the schools, by now giving the youngsters a Darwinism enhanced in many ways. Let them, for instance, be presented with a vivid visualization of the DNA chain, the core of our being, of how this genetic material probably originated by the workings of natural processes in the dawn of our planet's history, and of how a start is being made at putting it together today in our laboratories and thus creating the beginning of life. Let the children also be given pertinent information about the chemical basis of the changes in this genetic material, about our present load of mutations, about how natural and artificial selection operate, and about what has been involved in the grandscale processes that led to higher beings. Moreover, the place of man in the picture must be made clear: how natural selection has led to the development of mind, of social feelings, and of the biological equipment that made possible the development of of culture and of moral values. There is a wealth of illustrative detail that can be drawn upon to bring all this home. It can be made a fascinating story that will give our young people a strong sense of the meaning of life, not only for plants and animals in general, but for mankind in particular, and for them themselves.

We have no more right to starve the masses of our people intellectually and emotionally because of the objections of the uninformed than we have a right to allow people to keep their children from being vaccinated and thus to endanger the whole community physically. Fortunately, leaders of important religious groups are coming to realize their obligations in this matter. This is illustrated by the announcement made by the late Pope Pius a few years ago when he declared that the Catholic Church accepts the teaching of the theory of evolution. It is to be hoped that not many denominations will now feel that they can afford to lag beind in this respect, especially if we teachers pull together as we should from our end.

4. Our Rivalry with the Russians in the Pursuit of Truth

Since the first successsful Russian sputnik was launched, we have been hearing on all sides clamors for better and more effective teaching of science and mathematics in our schools. The President's committee, to our shame, reported last year that the Russians, whose population is not much greater than ours and who forty years ago were in large measure an illiterate people with a very weakly devel-

oped technology, already have more scientists and engineers than we do and are turning out more than twice as many science and engineering graduates per year as we do. China and Russia's other allies are starting to travel the same path. It is not too late for us to make adequate amends but unless we go to it with a will we will come to rate as poor seconds and the rest of the world will go the way of those who will have come to lead it.

If, however, we mean what we say about putting new life into our science teaching we must be willing to abandon the ostrich policy and to give up dangerous self-deceptions. This means that we must face all facts fully, especially the more fundamental ones, and must follow them out wherever they lead. Do we not feel that ignorance is ignoble? And are we not aware that knowledge is power? We say we stand for freedom. Let us then recognize that freedom means a freedom to create higher realities out of lower realities, not the privilege to retreat from reality into a world of illusions.

Now it happens that we have at least two great advantages over our competitors on the other side of the Iron Curtain in the effort to carry through the scientific revolution more successfully than they. First and foremost is the fact that we do have a strong tradition of freedom, intellectual, moral, and political, whereas their acts, and even their expressions of thought, are prescribed by an absolute dictatorship that brooks no challenge nor criticism. The principles of the Magna Charta, the Declaration of Independence, the Bill of Rights, the legal separation of Church and State, although by no means carried out in practice as fully as they should be, and although requiring continual struggle for their maintenance, adaptation to modern conditions, and further extension, nevertheless give us and other Western peoples a relative freedom to think and express our own thoughts, come to our own decisions, and live our own lives, that has fostered both our intellectual, our moral, and our economic development. Had it not been for the challenging of ancient authority thus engendered, science and technology would not have developed, and America would not have been discovered by Western Europeans.

Most of the people behind the Iron Curtain, however, never went through this historical process and in consequence fail to appreciate these truths. They take it for granted that politicians may dictate to scientists what the true principles of science are, that they may stifle opposing views, and that they may even prescribe in what directions research sould be pursued. For a time, and in certain limited lines of thought, this method can work out smoothly if we ignore the sufferers in concentration camps. However, in the long haul this policy means a cramping of higher creativeness and a loss of the very soul of science.

True science is the expression of a spirit that roves freely throughout the unknown, that is bound by no laws but those found by science itself, and that feels itself free at all times to question, investigate further, and modify even those laws themselves as it wins still better data. This does not mean, however, that true science can make no progress or that all its conclusions are equally uncertain. The reverse is true, that is, it is by this very procedure that science makes its progress and that it becomes ever more soundly based.

In accordance with this course of conduct, our own youth must be taught not only the facts and near-facts that science has attained but, what is even more important, they must be taught the heart of science's method. That is, they must be encouraged to take nothing—*but nothing*— on authority, to question everything freely, to voice these questionings openly and without being rebuked (on the contrary, being praised for it!), then to sift carefully and without bias the meaning of the evidence, to hold on to that which passes the tests, and to use these winnings as means for ever further progress. If at last the Russians also come to accept these methods, then they too will finally come to objectively reached conclusions similar to ours and so we will tend to meet on common ground. Till then, it is up to us to have the courage of our own professed convictions and to bring this intellectual freedom into ever fuller, more active practice. That is the only reliable road to the further development of science in all directions, to the higher technologies that this greater science will open up, and to a world in which all humanity proceeds hand in hand.

5. Our Conditional Advantage in the Biological Field

In the field of biology and of biological evolution in particular we have at present a more concrete advantage over the Russians, if we will but use it. This special advantage is an outgrowth of the more general one that has just been discussed. For it happens that the political powers in the Soviet Union have for more than twenty years exerted an especially destructive influence through their dictatorial policies in the field of genetics, the field that provides the most direct evidence concerning the way evolution works. In this crucial area of biology the Russian system of absolute authoritarianism has in fact proved fatal. It has literally killed off their great leaders in genetics, deprived their rank and file geneticists of the opportunity of doing further researches along their own lines, expurgated their curricula, textbooks and periodicals of any treatments of the subject, and brought up a whole generation on totally false biological doctrines. Central to these falsehoods is the doctrine of the inheritance of acquired characters and its corollary, that this is the means by which evolution works.

Only for the past year and a half have geneticists in Soviet countries been allowed to work and speak out somewhat more freely again. But the powers that be still deny that this subject is of any theoretical consequence, and are restricting geneticists to problems that they, the authorities, deem to have an immediately foreseeable value in practice. In this field, then, a field basic to the understanding of biological evolution and of everything that has resulted therefrom, we have a potential advantage of many years if only we will give this subject its due place in the education of our own youth. Moreover, this advantage is a very far reaching one. It extends even into the realms of human relations and of morals, inasmuch as genetic principles apply, as Darwin pointed out in his "Descent of Man," not merely to traits of form and color but, just as cogently, to the biological basis of those higher faculties of mankind out of which our social life and our morality have grown.

It would in many ways be a grievous step backward if the Soviet system, with its authoritarianism and its perversion of biological as well as social progress, were to win out in the struggle for the minds, hearts and bodies of men. We have in our own ways of life much more inspiring possibilities, if only we will grant them adequate opportunities for development in the hearts of our younger generation. At present we do not. Our youth are now being allowed to fall into the decadence of the commercialized hoopla that is carried to them over television and radio, in stadia and other public gatherings, and they are being on all sides encouraged in their rush to exploit privately and capriciously the opportunities of their high-powered automobiles and their increased allowances. In place of these distractions, they can and must be brought to realize the far richer fulfillment that is afforded them when they orient themselves to the modern view of the greatness of the world and of their own potentialities as revealed by modern science. Such orientation implies that they must learn to enjoy participation in the great cooperative interprises of humanity as a whole: in men's conquests over outer nature and over their own discordant, outdated pettinesses and provincialisms, and in the never ending work of improving their own inner beings. And as a primary basis for this reorientation, let the eyes of our youth be opened wider to the great struggles and victories of their forebears throughout billions of years. Let them discern in this the promise that, by common effort and the use of reason and good will, we can hereafter telescope what would in the past have been a thousand years of progress into every single year of our own times.

For beings who have been endowed by evolution with the social and moral natures of men, individual freedom soon turns into caprice, disillusionment, and decadence unless the individual sees himself as

an integral part of a greater whole, working with others in the pursuit of the higher freedoms of his community. In our modern age with its shrinkage of distances, this community now means the whole of mankind. This is the deepest lesson that the study of evolution, especially in its human aspects, can bring to the individual. We may well challenge the Soviets, with their doctrines of the economic man and of the universal class struggle, to offer anything that could be as inspiriting to youths or that could give so firm a sense of purpose and of direction to men's lives.

6. The Task Confronting Us.

But it will take a big determined effort on our part to bring these lessons home to everyone. They must be started with the little child. He must be shown in pictures from the beginning the magnificent panorama of evolution, with its fascinating successions and diversifications of plants and animals as they took over more and more of the environment and fitted in among each other like the parts of a vast picture puzzle. He must be brought to understand the daily efforts of the individual creatures whereby these advances and sometimes retrogressions came about, and he must be taught its lessons explicitly. Always his questioning and his raising of objections must be solicited, so that he can see that this and the other conclusions of science are not arbitrary doctrines imposed by any authority but have been arrived at by the most careful testing and criticism as well as with the help of imaginative flights. He should be taught to see, further, that the development of our understanding of this great movement of nature is not complete but is open for everyone's participation, and, finally, he should also learn to participate in the decisions as to what to do about it all.

We are not fulfilling our manifest obligation in teaching biology unless we open up these vistas to the child and also help him to delve into representative details of them. Here, then, we have both a glorious opportunity and a grave responsibility, such as no teachers have ever faced before.

Now while each teacher can do his bit by pulling individually in this direction as far as he practically can, that is far from enough. Our country has virtually stood still in this area for the whole century since Darwin and Wallace's discovery not because individual teachers failed to see the light but, for the most part, because they felt the pressure of ignorance too strong against them. This difficulty can be met, in part, by the practical measure of banding together, as has been done in the formation of our own local and national associations of teachers, and of then having the members of these groups make common cause with one another and work collectively on this matter,

so as better to protect each other and better to serve the community. Teachers may not expect to be treated otherwise than as underlings if they fail to stand by one another for the right to teach the tested truth.

In addition, the teachers' groups should actively sponsor work on more modern courses, curricula, and text books, and then give the fruits of this labor their collective approval. For these purposes the most up-to-date and efficient techniques are imperative if the new teaching is to win out. What are most needed now in this area are recorded lessons. These should show vividly in pictures, photography, animated diagrams, and suitable commentary the story of living things and the marvelous processes at work in the heart of them whereby the outer changes come about. Let us, for example, make use of the wonderful moving pictures recently taken at the Brookhaven National Laboratory that show, in non-technical fashion, how DNA reproduces itself, and how this notable discovery was arrived at. Let us also incorporate in our elementary biology courses the striking movies of mitosis recently made by the Polish biologist, Bajer. But these are only starters. The whole complex must be woven together and integrated so as to bring the real world of life, as we moderns see it, home to the multitudes of boys and girls who are so dependent upon us. Such recorded demonstrations, circulated from central offices, will not be so easily dismissed as heresy by the local community, and in time both parents and pupils will feel cheated if lessons so celebrated as these would become have not been presented in their own schools.

This by no means implies that teachers may, in their own teaching, sit back and wait until ideal recorded courses have been prepared and distributed. The work of reconstruction of our biology teaching should go on at all levels. The most immediate need is for the preparation and adoption of high-quality texts that give evolution its due axial position and deal with it outspokenly and adequately. The author of one of our most widely used high school biology texts has informed me that if he had insisted on this policy his book would have been rejected by the publishers. A representative of the publishers has next asserted that the fault was not theirs, since if they had been on the level with the children (an expression not used by him!) the book would have been rejected in Southern states in which the teaching of evolution is still illegal and by many textbook commissions and school boards in other parts of the United States as well, and that in that case they, the publishers, could not have afforded to publish the book. So the passing of the buck (*whose buck?*) will go on until the vicious circle is broken somewhere, by means of determined, concerted action.

Of course the publishers will make less profit if they have to publish two or three different texts instead of one that can be sold to all their customers. But if it were true, as claimed, that they actually could not afford to sell the text that is now most commonly used if its sale were cut in half then we might ask how the publishers of the texts now less popular manage to continue publishing, and how it is possible for texts to be published at all in countries like Holland or Sweden, where the total sale of a text in the given language must be only a small fraction of that which our own texts would have if they were restricted to the more enlightened areas. These considerations show that it would be quite possible even today to publish meritorious high school texts in biology without losing money on them, although of course the profits would be lower than if their sales were universal. Are we then to allow the urge for profits to keep our children and, through them, all our people benighted and a hundred years out of date in their world view? Can we afford to let the profit system destroy us? Here is where intervention both by government, by the general public, and by the professional groups most concerned—those of teachers and scientists—is in order to break the vicious circle. Or do we think democracy means that the bulk of the people should be given only the knowledge that satisfies the ignorant?

If teachers would stand together, and scientists too, in insisting that American children be taught the lessons of our own age in this time of world crisis, it might not be long before the demand for adequate texts and courses would be so widespread that the present antiquated and evasive texts would be rejected by an even larger fraction of our country than that fraction which now rejects texts that teach the truth. Then the publishers would begin to find their profits in the other pocket and would have to pay more regard to educational honesty. Then they would have to drop the complacency that holds: "if only we don't stir up trouble by making an issue of it the reform will come about gradually and naturally within another ten years." I have already waited for more than 50 years to see this policy succeed but our schools today seem even further behind contemporary knowledge in their treatment of evolution than they were half a century ago, and it is clear that another ten years at the same rate will only get us into worse arrears. It is up to us teachers, then, together to take the bull by the horns.*

Teachers who are ready for all this may give a token of their attitude by somehow joining, in 1959, in the great celebration of the hundredth anniversary of Darwin's "Origin of Species." The University of Chicago will have a symposium of some 50 or more scientists

* The three preceding paragraphs were not present in the address as spoken. They represent points which arose during personal conversations held at the meeting immediately after the address had been given.

on this theme next November (1959). But a commemoration of such great public importance should not be relegated to a relatively small group of specialists alone. Both educators and the public in this country profess to believe, with Jefferson, that education should be for everyone. Most people, moreover, oppose the doctrine, widely held by the intellectuals and nobility in renaissance Europe, that although the elite are entitled to dally with advanced ideas the masses should continue, for the good of the existing social structure, to be indoctrinated wholly with the ancient superstitions. If we, in this dangerous atomic age, reject so ignoble and undemocratic a view of human nature then let us create for ourselves in the year 1959 an opportunity of displaying our own appreciation of this theory of evolution, which forms the core of the biology that we *should* be teaching. For this epochal theory, that has till now been kept so veiled from our people, is surely the most stirring and significant discovery that man has ever made.

FEVER REMAINS MEDICAL MYSTERY

Doctors still do not fully understand what causes fever or where it starts. Furthermore, they have not yet established whether fever is really harmful or helpful. Doctors do know that children have a far greater temperature range than adults, often running between 97 and 100 degrees in a normal child, and in illness as high as 107.

HEREDITY, MULTIPLE SCLEROSIS LINK INDICATED BY TWIN STUDIES

A new study of twins links heredity as a possible cause of multiple sclerosis.

Heredity has long been under investigation as a possible factor in the cause of this disease of the central nervous system. Now, two doctors report the results of a study of twins suffering from multiple sclerosis in the Archives of Neurology and Psychiatry.

Among identical twins, both members of two sets definitely had multiple sclerosis, both of five sets apparently had it, and only one member of each of 22 sets was afflicted.

Among non-identical twins, both members of one set had the disease; both apparently had it in three sets, and one member each in 21 sets definitely had the disease.

Some of the twins exhibit partial symptoms. These symptoms may flower into the full clinical picture in many of the children, while others now free may develop the disease.

Yet, it seems highly unlikely that multiple sclerosis is caused by a genetic factor alone, they cautioned. Thus it is possible that a genetic factor may require the addition of an environmental agent before the disease can develop. When one of a set of twins does not develop the disease, it may be due to the fact that one of the pair has not yet encountered the unidentified environmental factor.

Multiple sclerosis was from 20 to 33 times as prevalent in over 1,000 relatives of the twins studied as in the general population. Currently, over 500,000 suffer from this and related diseases.

Changing Chemical and Biological Conditions in Oneida Lake, New York

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Introduction

Early investigations established important facts in relation to many scientific observations in the past. Since these early findings, in most cases, biological observations in the same areas have been allowed to lapse. This is true especially as regards ecological studies. There is a tremendous need in field work to go back over old territory, now many years later, in order to see what changes have occurred and to what extent the original findings are still valid. We are fortunate in having new techniques and equipment at our disposal now, so that we can make what are perhaps more accurate observations. But most importantly, we wish to know in what way Mother Nature has altered her ever varying face over the lapse of time. The study which follows is an illustration of an attempt to do exactly this.

Heraclitus, a Greek philosopher of the 5th century B.C., once said, "You cannot step twice into the same stream." Although this comment could be applied to any aquatic environment, it was as if Heraclitus was referring specifically to Oneida Lake, New York. Oneida Lake is located about 15 miles north of Syracuse and is the largest lake wholly within the State. Its limnological features have been described (1,2,3,4,5,6,7). Because of these various investigations, we are better able today to compare Oneida Lake as it was with Oneida Lake as it is now.

Chemical Changes in Oneida Lake

Associated with the fluctuation of numbers and species of fishes in the lake is the striking change that has occurred in the total alkalinity. A record of the alkalinity of Oneida Lake for the period of June 15 to September 15, 1927 may be found in a volume entitled, *A Biological Survey of the Oswego River System*. The total alkalinity expressed as $CaCO_3$ for Oneida Lake in 1927 for surface waters near Cleveland, New York, varied from a low of 9.7 ppm for June 29 to a high of 19.8 for August 24, with an average value of 13.5 ppm (7). In 1946 the New York State Conservation Department made a chemical investigation on Oneida Lake and tributary waters. A re-

port submitted (5) giving the results of this investigation found the average total alkalinity value for surface waters near Cleveland to be 87 ppm as $CaCO^3$ on August 1, 1946 (Table I). These workers also report that the August total alkalinity values within the lake varied only from 86 to 90 ppm with the average value for all stations at 88 ppm. During the summer of 1954 the surface water values for total alkalinity in Oneida Lake near Cleveland were found to be from 80 ppm to 84 ppm. The average value for all four stations in the lake was also 82 ppm of total alkalinity (Table I). This rise from 19.8 ppm in 1927 to 84 ppm of total alkalinity in 1954 represents an increase of 424%. Clark (8) estimated that, in the Saint Lawrence River drainage system (to which Oneida Lake belongs), 103.6 tons of soluble material are removed annually from each square mile of drainage. Since Oneida Lake has a drainage area of 1,265 square miles, this means that it would receive annually over 130,000 tons of soluble materials. This large amount would be expected to change the total alkalinity of the lake.

TABLE I

TOTAL ALKALINITY OF SURFACE WATERS FROM VARIOUS STATIONS IN ONEIDA LAKE AND ONEIDA RIVER FOR THE PERIOD FROM 1927 TO 1954, EXPRESSED AS PPM OF $CaCO_3$

Stations	1927[1]			1946[2]			1954		
	6/29	8/20	8/24	6/6	8/1	8/5	6/21	7/14	8/19
Big Bay				80		86	78	83	85
Upper South Bay				87		88			
Lower South Bay							80	84	85
Off Cleveland	9.7		19.8		87		80	83	84
Maple Bay							81	80	82
Oneida River near Brewerton		78		81		86	88	90	90

[1] Wagner (1928).
[2] Burdick and Lipschuetz (1946).

It is interesting to note that the alkalinity in the Oneida River below Brewerton has not changed as much as has the lake water. In 1927 (Table I) the summer total alkalinity value was 78 ppm, in 1946, 83 ppm, and in 1954, 89 ppm. The river at this point is greatly influenced by the waters of Big Bay and Chittenango creeks.

The increase in total alkalinity has direct effects on the other chemical conditions in the lake. Although there are insufficient data for exact conclusions, we know from chemical relationships that, by and large, the greater the alkalinity, the harder the water, the greater the tie-up of iron, the greater the reduction in the amount of free carbon dioxide present and the more marked the change in the nitrate-

phosphate ratio. Unquestionably these new conditions result in different environmental factors which make unprecedented demands on the lake biota.

BIOLOGICAL CHANGES IN THE LAKE

The phytoplankton populations, since they are among the simplest forms in any lake, are usually with the first organisms which show change in a lake, not only from their qualitative but also from their quantitative aspects. Muenscher (6) reported the diatoms to be the predominant group, especially during August and September. The genera *Fragilaria* and *Tabellaria* were the outstanding organisms at this time, while *Asterionella* and *Stephanodiscus* were the major forms in June and July, with *Stephanodiscus* being the lesser component. The blue-greens were represented principally by *Anabaena* and *Microcystis* with traces of *Gloeotrichia*. At no time did the green algae form any appreciable fraction of the total population.

Oneida Lake has blooms that occur periodically during the summer and autumn, although not all of the blooms are of sufficient magnitude to attract general attention. On August 24, 1942, however, *Microcystis* and *Rivularia* had reached such a concentration that the odor from their decay caused the bathers to abandon many of the beaches. On October 10, 1944, there was a bloom of *Microcystis* which, upon its decay, resulted in the death of many fishes. During the summers of 1954 and 1955, the principal phytoplankton organisms were *Gloeotrichia* and *Aphanizomenon* while *Microcystis* was scarce and *Anabaena* comparatively rare. Only a few fragments of diatoms or green algae were present in either net or centrifuged samples. During the summer of 1956, on one occasion, *Stephanodiscus* was the predominant species, but this was the exception rather than the rule. The phytoplankton population for the summer months in Oneida Lake is now a predominantly blue-green one, whereas in 1927 it was primarily a diatom population. This change is correlated with the increase in total alkalinity. A review of the limnological literature will show that lakes with a total alkalinity range below 25 ppm are those primarily dominated in the summer months by diatoms while lakes with a total alkalinity between 45 and 125 ppm are dominated by the blue-green algae.

It is difficult because of inherent differences in methods to compare plankton counts of various workers. Fortunately, however, if one cares to, one can compare gravimetrically the sestons of lakes. Table II shows the changes in seston in Oneida Lake during the past 27 years. The average organic weight of the seston in 1927 was 2.25 mg/liter while that for the summer of 1954 was 12.7 mg/liter, an increase of 564%. This increase in seston is not only due to the increased

TABLE II

QUANTITIES OF ORGANIC MATTER AND ASH IN ONEIDA LAKE SURFACE WATERS FOR THE SUMMERS OF 1927 AND 1954. WEIGHTS EXPRESSED IN MG./1

Date		Organic Matter	Ash
1927[1]	6–28	2.35	2.50
	7–12	2.35	2.10
	7–26	1.80	2.50
	8–23	2.50	2.15
	Average	2.25	2.31
1954	6–21	12.1	14.2
	7–12	9.1	11.1
	7–23	14.1	16.0
	8–3	12.7	13.2
	8–19	15.6	17.0
	Average	12.7	14.3

[1] Muenscher (1928).

amount of phytoplankton, but undoubtedly also reflects an increase in the zooplankton. This would be expected to follow an increase in the primary producers.

The change in the number of "weed beds" in the lake is also a significant occurrence. Baker (4) reports large numbers of aquatic higher plants in the western end of the lake. Many of these beds are now gone, not only because of the fluctuation of water level, but also due to the large numbers of homes now established along the shore. It has been estimated by Robert Landgraff, a resident of the lake for many years and a special Conservation Department representative, that there are now 6,000 cottages on the lake shores, an increase of nearly 50% in 20 years. It would seem that a reduction in the number of vegetation beds would affect the invertebrate fauna, especially the mollusca and mayfly populations. Further investigations are necessary before these values can be ascertained.

CHANGES IN THE FISH FAUNA

There are undoubtedly many normal unrecorded fluctuations in the fish population of any lake. These are due to the variation and interaction of the physical-chemical-biological factors. When this condition is further complicated by man-made influences, a Herculean knot is formed. Such was the case in Oneida Lake. Although the Atlantic salmon (*Salmo salar* Linnaeus) was reported by Adams and Hankinson (2), this was done from an account in 1842. It is doubtful whether this species, once abundant, was present in Oneida Lake since

the beginning of the 1900's. This extinction of a species is but part of the normal process of evolution. The fate of the Tullibee (*Coregonus artedi tullibee* LeSueur) or Oneida whitefish is another example of normal dynamics occurring in nature. It was reported by Mr. Hiram Coville of Brewerton, New York, in 1914 that four or five tons of tullibees usually were handled each year (1). This crop had been nearly depleted by 1932. The decline may be associated with the large population of sea lamprey (*Petromyzon marinus* Linnaeus). Large numbers of dead fish with lamprey scars once were common in Oneida Lake. As the Tullibee became few in number, the number of lampreys also became less prominent. Until the summer of 1957, the lampreys remained rather few in number, as estimated by dead fish having large scars. During that summer and this season, the number of fish dead with lamprey scars in the lake has increased. It is also of interest to note that during the Spring seining of 1958 for pikeperch a Tullibee was captured in the seine. This was the first that had been seen by the seining crew at the Constantia Hatchery for many years. It will be interesting to see what happens next in this predator-prey relationship.

In 1909, at Caughdenoy, New York, which is four miles downstream from the mouth of Oneida Lake, a concrete dam was built in connection with the New York Barge Canal program. Since much of Adams' and Hankinson's (2) fish data were collected in 1915–16, there was little opportunity for them to observe what effects the dam had on fish. In 1913, 41,635 pounds of eels (*Anguilla rostrata* LeSueur) were collected from the Oneida-Oswego River system. Today it is rare to find even one eel in Oneida Lake. Thus the leading commercial fishing industry of Oneida Lake in the early 1900's is but a memory today, the major reason being that the eels cannot get through the locks of the canal.

In 1951 the concrete, immovable type of dam at Caughdenoy was replaced with a Painter type dam, having a movable gate that may be raised or closed. This replacement of an impermeable barrier with a more permeable one permitted the free movement of fishes up the Oneida River into the lake. Among the fishes that were opportunists and took advantage of this situation were the gizzard shad (*Dorosoma cepedianum* LeSueur), the white perch (*Roccus americana* Gmelin) and the sheepshead (*Aplodinotus grunniens* Rafinesque). These species are exotic to this region and are very prolific. They, therefore, can exert a marked effect on the dynamics of the lake.

Gizzard shad undoubtedly reached the lake through the Barge Canal system, inasmuch as they were observed at a number of other nearby sections of the Canal previous to their appearance in Oneida Lake. Specimens were first collected near Lake Ontario in the canal

lock at Minetto in 1952. They were reported dying there in considerable numbers. A year or so later, yearlings were collected at the Montezuma Wildlife Refuge during the rotenone treatment for carp control. The lock tender at nearby May's Point reported that large numbers were passing through the lock that autumn. The first evidence of gizzard shad at Onondaga Lake occurred during the summer of 1953, when dead fish were observed on the beaches. They soon were in abundance in this lake. The species may have reached Oneida Lake at about the same time, although numbers of young fish did not become conspicuous until 1954. The advent of this large population of gizzard shad seemed to have had a marked effect on the pikeperch (*Stizostedion vitreum* Mitchill). Forbes (9) reported that a single pikeperch may eat in a year at least 600 gizzard shad. During the summer of 1954 and the spring of 1955, pikeperch fishing in Oneida Lake was in its poorest in over 50 years. The pikeperch stripped for eggs in March, 1955, were all fat, showing that they had had plenty to eat and did not need the fisherman's small offering.

The hatchery at Constantia annually stocks Oneida Lake with 400–500 million pikeperch fry. These are reared from eggs of adults captured in relatively shallow water of about one mile extent along the 65 miles of shore-line. Obviously, not all of the shore areas are as suitable for spawning as are others, but it must be recognized that the spawn taken from the pikeperch, great as it may seem, represents only a small fraction of the total egg production. Inestimable numbers of immature pikeperch naturally are lost through predation and other causes. However, the results of the netting operations by the hatchery force indicate that there has been a constant increase in survivors in recent years, particularly in 1956–57. The buffer effect of gizzard shad may have had some bearing on this higher survival rate. The winter of 1956 and the springs of 1957 and 1958 were especially good ones for the pikeperch fisherman. It is of interest that, by the spring of 1958, this large population of gizzard shad apparently had nearly disappeared from Oneida Lake. Intensive seining in the lake by various groups revealed from none to only a few specimens. It would seem as if this population of gizzard shad was only migrating through the lake.

The white perch, a characteristic fish of brackish waters along the Atlantic coast, invaded Central New York several years ago, as reported by Dence (10). It was first observed at Cross Lake, where it developed very rapidly and became extremely abundant. The species extended its range first to Onondaga Lake and, more recently, to Oneida Lake. The appearance of adults in considerable numbers during the early part of April, 1955, in the nets operated by the Oneida Hatchery crew for obtaining pikeperch spawn, is significant since rela-

tively few, if any, were observed there in previous years. Some of the specimens taken locally by anglers exceed a half-pound in weight, but the majority of those observed in the nets weigh somewhat less. The rapid build-up of white perch, however, indicates that survival of the young is much greater than it is in most native species.

The latest exotic species to become plentiful in the lake is the sheepshead (*Aplodinotus grunniens* Rafinesque). Although the sheepshead occurred in the general drainage system, particularly in Cross Lake, it apparently did not reach Oneida Lake until recently, since its presence was not noted until Spring, 1957, when considerable numbers were encountered in the pikeperch seining operation.

Although all of these exotics would be expected to compete with the native fish for food, as yet this does not seem to present difficulty. Instead, it would appear that they are beneficial to the pikeperch and the yellow perch (*Perca flavescens* Mitchill). The yellow perch fishing in Oneida Lake, as reported by the anglers, was becoming steadily poorer each year from the early 1930's until about 1948. Since that time to the present, judging from information gathered from fishermen and the reports found in the sportsmen's column of the Syracuse *Herald-Journal*, the yellow perch fishing has become significantly better, both in relation to numbers caught and in the size of the fish.

Undoubtedly, certain other species may have invaded the lake on various occasions, since they occur in the watershed, but have failed to become well established. Among these may be listed the lake sturgeon (*Acipenser fulvescens* Rafinesque), the gar pike (*Lepisosteus osseus* Linnaeus), moon-eyes (*Hiodon tergisus* LeSueur), muskellunge (*Esox masquinongy* Mitchill) and the rainbow trout (*Salmo gairdneri* Richardson). Any organism new to an environment must adjust, die or migrate. The fishes of Oneida Lake are excellent examples of this ecological principle.

Since Oneida Lake today has diverged to such an extent from what it was in 1927, it will indeed prove interesting to see what conditions prevail in 1981 and whether Mozley's (11) statement still applies. He stated: "Oneida Lake is one of the most productive lakes I have seen on any continent."

Bibliography

1. Adams, C. C. and T. L. Hankinson. 1916. Notes on Oneida Lake fish and fisheries. Trans. Amer. Fish. Soc. 45: 154–169.
2. Adams, C. C. and T. L. Hankinson. 1928. Ecology and economics of Oneida Lake fish. Roosevelt Wildlife Annals, Vol. 1 Nos. 2 and 3: 239–548.
3. Baker, F. C. 1916. The relation of mollusks to fish in Oneida Lake, New York. N. Y. State College of Forestry, Tech. Publ. No. 4, 366 pp.
4. Baker, F. C. 1918. The productivity of invertebrate fish food, on the bottom of Oneida Lake, with special reference to mollusks. N. Y. State College of Forestry, Tech. Publ. No. 9, 264 pp.

5. BURDICK, G. E. AND M. LIPSCHUETZ. 1946. A report on the investigation of Oneida Lake. State of New York Conservation Dept. Bureau of Fish, Albany, N. Y.
6. MUENSCHER, W. C. 1928. Plankton studies of Cayuga, Seneca, and Oneida Lakes. In: A Biological Survey of the Oswego River System, Suppl. 17th Ann. Rept. N. Y. Cons. Dept. 1927, 140–157.
7. WAGNER, F. E. 1928. Chemical investigation of the Oswego watershed. In: A Biological Survey of the Oswego River System, Suppl. 17th Ann. Rept. N. Y. Cons. Dept. 1927, 108–133.
8. CLARK, F. W. 1924. The composition of the river and lake waters of the United States. U. S. Geol. Surv. Professional Papers No. 135, 199 pp.
9. FORBES, S. A. 1880. The food of fishes: Acanthopteri. Bull. Ill. State Lab. Nat. Hist. 1(3); 19–70.
10. DENCE, W. A. 1952. Establishment of white perch, *Morone americana*, in Central New York. Copeia (3): 200–201.
11. MOZLEY, A. 1954. An introduction to Molluscan ecology: distribution and population studies of fresh-water Mollusca. H. K. Lewis & Co. Ltd., London

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HYDROGEN ATOM MEASURES EARTH'S MAGNETIC FIELD

The proton, nucleus of the hydrogen atom, has been harnessed to measure the horizontal and vertical forces of the earth's magnetic field.

The Coast and Geodetic Survey, reported that a new instrument, the "proton vector magnetometer," has been successfully tested at the Survey's Fredericksburg (Va.) Magnetic Observatory.

The improved version of the magnetometer also has potential applications in such fields as oil explorations and oceanographic investigations. Earlier versions have been used in rockets and miniaturized models are scheduled for use in satellites.

The previous instruments were capable of measuring only the overall force of earth's magnetic field, not the direction. The new magnetometer can measure with great precision the magnetic force in both a horizontal and vertical direction, as well as the overall intensity.

By using polarizing electric coils around a plastic cup containing about a pint of distilled water, the instrument introduces a magnetic field that causes the spinning protons of the hydrogen atoms to whirl at right angles with the earth's magnetic field, instead of in line with it as they normally do.

When the induced magnetic field is eliminated, the protons gradually return to their normal path, creating a small alternating current as they do so. The frequency of this current, which can be precisely measured, is directly related to the magnetic field strength.

NEW COMPOUNDS FORMED 60 MILES DEEP IN EARTH

Minerals contained in the earth's abundant granite and basalt deposits are changed into new compounds at depths of less than 60 miles beneath the surface of the earth. The transformations occur in much the same way that graphite is changed to diamond under great pressure.

Quartz, albite feldspar, and orthoclase feldspar, which are the common minerals of granite, are transformed at different pressures. Quartz, for instance, changes into coesite at 500 degrees centigrade and 19,000 atmospheres of pressure (one atmosphere is about 14.7 pounds per square inch). This pressure is equivalent to a depth in the earth of about 40 miles. Albite feldspar breaks down into both jade and quartz at a pressure of about 13,000 atmospheres at 500 degrees Centigrade.

Problem Department

Conducted by Margaret F. Willerding

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2634. *A. R. Haynes, Tacoma, Wash.*

2641. *Russell H. Godard, Corvallis, Ore.*

2637. *Teresa Saks, Hellertown, Pa.*

2637. *Carol Woodring, Hellertown, Pa.*

2640. *J. Byers King, Denton, Md.*

2637. *John F. Osinski, Jr., Salisburg, Md.*

2637. *John Nayler, Calgary, Alberta, Canada.*

2630, 2632, 2636, 2637, 2638, 2640, 2641, 2644, 2645, 2646. *C. W. Trigg, Los Angeles, Calif.*

2642. *Proposed by B. C. Barrios, Cleveland, Ohio.*

Find an expression for the number of helically formed rods of diameter d that can be wrapped around a right circular cylinder of diameter D, such that each rod will touch the rod next to it. L is the lead of the helix, i.e., the distance parallel to the axis of the cylinder through which a point on the helix advances one revolution.

Solution by C. W. Trigg, Los Angeles City College

The number N is not a function of the length of the right circular cylinder, nor of D. Indeed, $N=[L/d]$, where $[x]$ is the greatest integer in x.

2647. *Proposed by John Nayler, Calgary, Alberta, Canada.*

One disc of 20 inches diameter and one of 10 inches diameter are cut from a 30-inch diameter disc of plywood. What is the largest disc that can be cut from the remainder of the plywood?

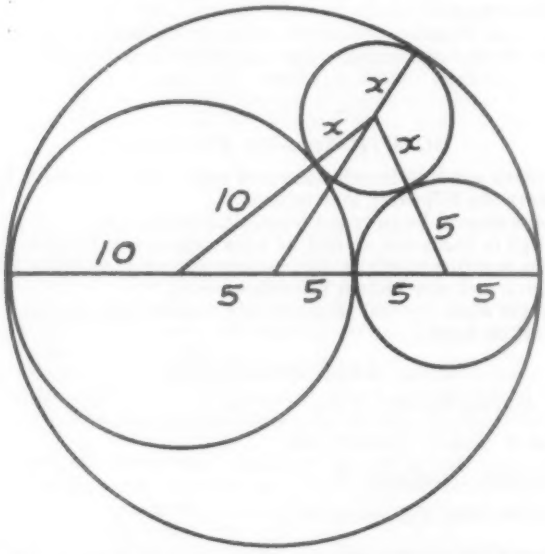
Solution by C. W. Trigg, Los Angeles City College

By applying Stewart's theorem to the triangle formed by the lines of centers in the figure, we have

$$15(15-x)^2=10(10+x)^2+5(5+x)^2-15\cdot10\cdot5.$$

This equation simplifies to $140x=600$. Hence, the largest disc that can be cut from the remainder of the plywood is one with a radius of $30/7$ inches.

Editor's Note: This problem is a repetition of Problem 2640 which appeared in the Oct. 1958 issue of School Science and Mathematics.



2648. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

For real values of x, determine whether x^3+1 is larger than x^2+x.

Solution by the Proposer

$$\begin{aligned}x^3+1-(x^2+x)&=x^3-x^2-x+1\\&=(x^2-1)(x-1)=(x-1)(x+1)(x-1)\\&=(x+1)(x-1)^2\end{aligned}$$

which, since $(x-1)^2$ is positive, is negative for x less than -1 and positive for x greater than -1. The expressions are equal if $x=-1$; the first expression is the larger if x exceeds -1, the smaller if x is less than -1.

Solutions were also offered by M. Barnebey, Tougaloo, Miss.; T. C. Smith, Austin, Texas; and C. W. Trigg, Los Angeles, Calif.

2649. *Proposed by Felix John, Philadelphia, Pa.*

If the sides of a triangle are in arithmetic progression, the corresponding altitudes are in harmonic progression.

Solution by C. W. Trigg, Los Angeles City College

In any triangle, the area,

$$S=\tfrac{1}{2}h_a a=\tfrac{1}{2}h_b b=\tfrac{1}{2}h_c c.$$

It is given that $b-a=c-b$, so

$$\frac{2S}{h_b}-\frac{2S}{h_a}=\frac{2S}{h_c}-\frac{2S}{h_b}.$$

Thus,

$$1/h_b-1/h_a=1/h_c-1/h_b,$$

which proves the proposition.

Solutions were also offered by A. R. Haynes, Tacoma, Wash.; William E. Hoff, Ferguson, Mo.; C. N. Mills, Sioux Falls, S. D.; and the proposer.

2650. *Proposed by C. W. Trigg, Los Angeles City College.*

In how many essentially different ways may 27 congruent cubes, of which 9 are red, 9 are white, and 9 are blue, be assembled into a $3\times3\times3$ cube so that no row, column, or pile contains two cubes of the same color?

Solution by the Proposer

If any such arrangement exists, there must be at least three, each with a different colored block in the center.

Suppose three cubes of each color are arranged into a square layer with no color repeated in any column or row. Then there are 6 permutations of the columns and 2 permutations of the two bottom rows of each of these to give 12 apparently different arrangements. But any one of these may be plane rotated into three others. Hence there are only 12/4 or 3 basic square arrays.

The arrangements of the 27 small cubes into a large cube consist of the 6 permutations of the 3 basic square arrays:

Layer	*M*	*N*	*N′*	*P*	*P′*	*M′*
	R W B	*R W B*	*W B R*	*W B R*	*B R W*	*B R W*
Bottom	*W B R*	*W B R*	*B R W*	*B R W*	*R W B*	*R W B*
	B R W	*B R W*	*R W B*	*R W B*	*W B R*	*W B R*
	W B R	*B R W*	*B R W*	*R W B*	*R W B*	*W B R*
Middle	*B R W*	*R W B*	*R W B*	*W B R*	*W B R*	*B R W*
	R W B	*W B R*	*W B R*	*B R W*	*B R W*	*R W B*
	B R W	*W B R*	*R W B*	*B R W*	*W B R*	*R W B*
Top	*R W B*	*B R W*	*W B R*	*R W B*	*B R W*	*W B R*
	W B R	*R W B*	*B R W*	*W B R*	*R W B*	*B R W*

Now M goes into N which goes into P by cyclic permutation of R, W, B. Also, cube M may be rotated about a diagonal into cube M'. Hence there are but 3 essentially different ways (M, N, P), to assemble the 27 cubes.

A solution was also offered by M. Barnebey, Tougaloo, Miss.

2651. *Proposed by Brother Norbert, Chicago, Ill.*

Prove that the sum of the radii of the three escribed circles of a triangle is equal to the radius of the inscribed circle plus four times the radius of the circumscribed circle.

Solution by Cecil B. Read, University of Wichita, Wichita, Kansas

Often the most satisfactory solutions are merely a reference to a standard source. This problem is found on page 83 of the second edition of Altschiller-Court, *College Geometry* (original edition, page 72–73, section 113).

Solutions were also offered by A. R. Haynes, Tacoma, Wash.; C. N. Mills, Sioux Falls, S. D.; and C. W. Trigg, Los Angeles, Calif.

2652. *Proposed by C. N. Mills, Sioux Falls College, South Dakota.*

Given

$$f(x)=ax^3+bx^2+cx+d \quad \text{and} \quad g(x)=dx^3+cx^2+bx+a.$$

In order that $f(x)$ and $g(x)$ have a common linear factor, show that the necessary conditions are

$$a-b+c-d=0,$$

and

$$a+b+c+d=0.$$

Solution by the Proposer

Dividing $f(x)$ by $(x+k)$, the remainder is

$$d-ck+bk^2-ak^3=0.$$

Dividing $g(x)$ by $(x+k)$, the remainder is

$$a-bk+ck^2-dk^3=0.$$

Solving these equations, gives $k=\pm 1$. Substituting the value of k in either equation gives the required results.

A solution was also offered by C. W. Trigg, Los Angeles, Calif.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2649. *Paul J. Edelson, New York, N. Y.*

2649. *Henry Bell, III, and Bob Lawless, Bastrop, Texas.*

PROBLEMS FOR SOLUTION

2671. *Proposed by Wm. W. Johnson, Cleveland, Ohio.*

An electric light is suspended at a point 20 ft. above and 30 ft. to one side of the center line of a straight horizontal sidewalk. A man 6 ft. tall started from the point opposite the light and walked along the sidewalk at the rate of 4 ft. per sec. How far was he from his starting point when his shadow lengthened at the rate of one ft. per second?

2672. *Proposed by Cecil B. Read, Wichita, Kansas.*

Suppose a represents any of the digits from 1 to 9 in our ordinary decimal system. Clearly for $a=9$,

$$aaa<aa^a<a^{aa}<a^{a^a}.$$

Determine, other than by trial and error, the least value of a for which the inequality is true.

2673. *Proposed by C. W. Trigg, Los Angeles, Calif.*

Given:

$$M=(b-c)^2(b+c-2a)+(c-a)^2(c+a-2b)+(a-b)^2(a+b-2c).$$

Express M, (1) in factored form; (2) as the sum of three cubes; and (3) as the sum of two cubes.

2674. *Proposed by John Nayler, Calgary, Alberta, Canada.*

Every edge of an aluminum cube of 3 in. side is bevelled 1 in. by 1 in. at 45°. Calculate the volume of metal removed.

2675. *Proposed by J. B. Love, St. Davids, Pa.*

Given 6 points, no 4 coplanar and no 3 colinear. Connect all points to every other point and color the resulting line segments either black or red. Prove that for one of the triangles formed, all three segments forming the triangle are one color.

2676. *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the equation

$$(x+1)^6-1344x=(x-1)^6.$$

Why does the equation have only five roots?

Books and Teaching Aids Received

THE PRACTICAL DICTIONARY OF ELECTRICITY AND ELECTRONICS, by R. L. Oldfield. Cloth. Pages vii+216. 13.5×21 cm. American Technical Soceity, 848 E. 58th Street, Chicago 27, Ill. Price $5.95.

EARTH, AIR AND SPACE, A Symposium on The International Geophysical Year, September 12, 1957. Paper. Pages vi+37. 21.5×28 cm. Contributions of The American Museum—Hayden Planetarium, Series 1, Publication 1. 1958.

MEN AT WORK ON THE WEST COAST, by Henry B. Lent. Cloth. 128 pages. 15×20.5 cm. 1959. G. P. Putnam's Sons, 210 Madison Ave., New York, N. Y. Price $3.00.

AN INTRODUCTION TO SETS AND THE STRUCTURE OF ALGEBRA, by W. R. Krickenberger and Helen R. Pearson. Paper. Pages iv+31. 16×23 cm. 1958. Ginn and Company, Statler Building, Boston 17, Mass.

DICTIONARY OF ASTRONOMY AND ASTRONAUTICS, by Armand Spitz and Frank Gaynor. Cloth. Pages vi+439. 14.5×21 cm. 1959. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. Price $6.00.

MODERN HIGH SCHOOL PHYSICS, A Recommended Course of Study, by David Vitrogan. Paper. Pages viii+88. 14×21 cm. 1959. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.50.

TEACHING A UNIT IN ASTRONOMY, by J. Russell Smith. Cloth. 149 pages. 13×20.5 cm. 1959. Vantage Press, Inc., 120 W. 31 St., New York 1, N. Y. Price. $2.75.

ANIMALS THAT HELP US, by Carroll Lane Fenton and Herminie B. Kitchen, Cloth. 128 pages. 16×21.5 cm. 1959. The John Day Co., Inc., 210 Madison Ave., New York, N. Y. Price $3.50.

SPACE PRIMER, An Introduction to Astronautics. Paper. Pages vii+72. 9×21.5 cm. 1959. Convair Division of General Dynamics Corporation, San Diego, Calif. Single copies free.

SELECTED READINGS IN GENERAL CHEMISTRY, Compiled by William F. Kieffer and Rober K. Fitzgerel. Reprinted from the 1956–1958 volumes of *Journal of Chemical Education*. Paper. 128 pages. 21.5×28 cm. 1959. Journal of Chemical Education, Easton, Pa. Price $2.00.

ELEMENTS OF BIOLOGY, revised by Ruth A. Dodge. Cloth. Pages x+740. 16×23 cm. 1959. Allyn and Bacon Co., Boston, Mass.

ROCKET SCIENCE FOR AMATEURS, by L. E. Lewis, Jr. Paper. 50 pages. 1958. 21.5×28 cm. Sooner Science Publications, Box 145, Norman, Oklahoma. Price $2.00.

Book Reviews

TEACHING HIGH SCHOOL SCIENCE: A SOURCEBOOK FOR THE BIOLOGICAL SCIENCES by Evelyn Morholt, *Chairman, Dept. of Biological Sciences, Fort Hamilton High School, Brooklyn, N. Y.*, Paul F. Brandwein, *Director, Division of Education, Conservation Foundation, General Editor and Consultant to Schools, Harcourt, Brace* and Alexander Joseph, *Science Department, Bronx High School of Science*, Cloth. pages 506, 16×22.9 cm. 1958. Harcourt, Brace and Company, Inc. New York.

This book contains a virtual storehouse of teaching techniques, procedures, demonstrations, projects, experiments and other suggestions pertinent to biology. It is divided into four sections. Section one is the introduction which deals primarily with suggested procedures which might be used in the development of a teaching technique. Section two, titled *Techniques in the Classroom*, is divided into fifteen chapters, each having a very complete series of teaching techniques, demonstrations, capsule lessons and a section uniquely called Peoples, Places and Things. Complete directions and materials needed for the wide selection of demonstrations are clearly stated. The capsule lessons consist of a variety of ideas designed to help the teacher get started in the classroom in a particular subject area. Peoples, Places and Things contain lists of books, pamphlets, films, filmstrips and other materials dealing with the chapter topics. Section three, titled *Special Techniques*, gives instructions for the anatomical study of both plants and animlas, microprojection, histological techniques as well as care of plants and animals in the classroom. It also includes instructions for the preparation of solutions, models, slides, charts and a chapter outlining essential facilities for maintaining a school science program. Section four is the appendix which contains lists of books for a science library, films and filmstrips, free and inexpensive materials, reference tables and a directory of supply houses.

This book could be used by both elementary and secondary school teachers for the majority of demonstrations and techniques presented may easily be adapted to all grade levels and all groupings within a biology curriculum.

It is indeed a "sourcebook," containing a wealth of useable information which should be in the possession of all who teach a biological science. It should especially be welcomed by those who do not have years of teaching experience behind them.

ROLAND R. GOINS
Arlington High School
Arlington Heights, Illinois

UNDERSTANDING AND TEACHING ARITHMETIC IN THE ELEMENTARY SCHOOL, by E. T. McSwain, *School of Education, Northwestern University*, and Ralph J. Cooke. Cloth. Pages xi+420. 13.5×21 cm. 1958. Henry Holt and Company, 383 Madison Ave., New York, New York.

The current books on the teaching of arithmetic have been in the main either books of problem material with little emphasis on methods or methods books with little problem material provided by the authors for applying the methods which have been suggested by them. The teacher of a methods class is of course conscious of the necessity for provision for exploring both of these aspects in his course.

The authors of the book being reviewed have succeeded to a large extent in providing challenging materials in both categories. The headings of several chapters suggest this dual purpose in terms of the Meaning and Use of Whole Numbers, Fractions, Decimals, Measurements, and Percentage.

In the main the material is well organized and fairly complete through the sixth grade level. It is certainly too sketchy in its treatment of percentage and other seventh and eighth grade topics. Since seventh and eighth grade content is often included in special courses for junior and senior high school students, this is not a major criticism.

Much space in the early chapters is devoted to explaining the meaning of the fundamental processes as applicable to whole numbers, fractions, and decimals with many thoughtful exercises provided to help fix the meaning and application of the processes in the minds of prospective teachers. Each concept presented is followed by what the authors call the "Generalized Rule."

The chapter on problem solving could be improved by the inclusion of additional challenging problem materials and a discussion of techniques such as: the use of diagrams, unit analyses, formulas, and equations; as suggested methods of attack in problem solving.

A section of the book is devoted to curriculum sequence which is undoubtedly the sequence used by the authors in their own textbook series. Some of this suggested sequence might be questioned by authors of other textbook series.

An unusual feature is the inclusion of a Basic Vocabulary of 110 terms which are defined by the authors. Such a list is always subject to criticism as being either too inclusive or not inclusive enough. Many words such as minuend, subtrahend, base, percentage, and so on are used by the authors in the book but are not included in this basic list. One must conclude that the authors feel that there are two basic vocabulary lists—one for the teacher and another for his students.

The value of drill or practice exercises is not stressed as far as the reviewer was able to determine. Are we then to conclude that the right kind of drill and practice are undesirable or unnecessary?

An excellent bibliography of textbooks and periodical articles in the teaching of arithmetic is included. However, the articles cited are almost exclusively from *The Arithmetic Teacher*. The reviewer feels there must be many articles of similar interest to arithmetic teachers from other periodicals as well.

In the main the book is well written and fills a much needed place among the many methods books available at present. In the opinion of the reviewer, persons who are teaching methods courses in elementary arithmetic should consider this book along with other leading textbooks in arithmetic methods.

HERBERT H. HANNON
Western Michigan University
Kalamazoo, Michigan

GUIDE TO THE MICROSCOPE, by Arthur Beiser, *Assistant Professor of Physics, New York University*. Cloth, Pages 127. 13.5×20.3 cm. 1957. E. P. Dutton & Co. Inc., New York. Price $3.25.

Guide to the Microscope is a book written for those who view the world of little things primarily as a hobby or as a matter of curiosity. One does not need any previous formal training to understand the materials contained within the body of the text. Because of this it is written in a very non-technical language, easy to understand—easy to follow.

The author begins with a very brief history of the microscope followed by such topics as purchasing a microscope, procedures for viewing one-celled organisms, blood, fungi, algae, body cells, metals, clothing and many other common everyday things found in the local environment. One of the highlights of the book is the section on photomicrography with its brief by simple instructions on how to take both still and moving pictures through the microscope. As in the other topics, however, detail is omitted and the reader must devise his own methods if he wishes to pursue the subject more deeply. The plates included are well selected, the drawings are well done, scientifically accurate and adequately illustrate the various subjects discussed. Sketches by Sol Ehrlich help to introduce each chapter.

This book then is strictly for the non-scientifically trained person hence would be of less value to anyone having previous training as to the use of the microscope.

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ARITHMETIC FOR COLLEGES, Rev. Ed., by Harold D. Larsen, Albion College. Cloth. Pages xiii+286. 13.5×20 cm. 1958. The Macmillan Co., 60 5th Ave., New York 11, N. Y. Price $5.50.

This book is designed for the college student who is preparing to teach elementary arithmetic. The content, as is proper, includes many topics which would be omitted or given brief treatment in an elementary text, and other topics are treated from a more advanced viewpoint. This reviewer was particularly pleased with the historical material.

The first chapter discusses the development of our number system, numeration (an unusually good treatment), exponential notation, other scales of notation, numerology. The second chapter discusses casting out nines and elevens. Succeeding chapters (addition, subtraction, multiplication, division) include historical material, short methods and checks, operations where the base is other than ten. There are chapters on common and decimal fractions, percentage, and units of measure. The chapter on approximate numbers seems very well written; it is pleasing to find divergence in practice pointed out (and a clear statement of which practice is used by the author). Even though this reviewer prefers what the author calls a "sophisticated" rule for rounding off numbers, he cannot quarrel with the statement made, and is pleased to find mention of the other practice (a matter often omitted by authors). There is a minor misprint in the footnote on p. 208.

There is a brief chapter on the slide rule. Some may question the value of such material with its complete omission of the underlying theory (the reviewer could not find the word "logarithm" in this chapter). The material could be omitted with no loss of continuity.

There is a bibliography of over 50 items. Only one is from a periodical—this reviewer feels there are many other periodical references of equal or far greater value than the one cited.

For the stated purpose, this seems an excellent text.

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University of Wichita
Wichita, Kansas

MAN AND NUMBER, by Donald Smeltzer, *formerly Lecturer in Education, King's College, Newcastle upon Tyne.* Cloth. Pages viii+114. 12×18.5 cm. 1958. Emerson Books. Inc., 251 West 19th Street, New York, New York. Price $2.50.

This small book gives an interesting account of the development of numbers, number sense, and simple calculation methods. Although there is little if any of the material which is not available in other sources, this inexpensive book does furnish a considerable amount of material and would be a valuable addition to a private or school library which is somewhat lacking in this field.

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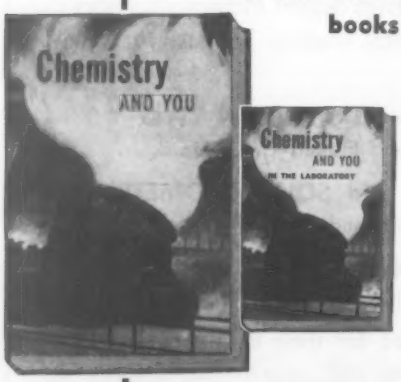

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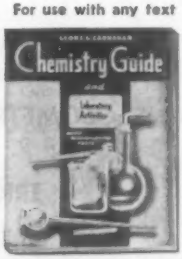

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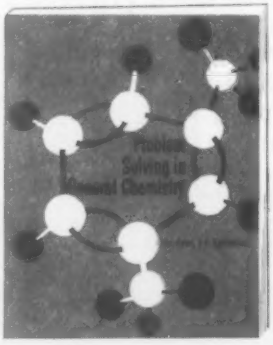

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